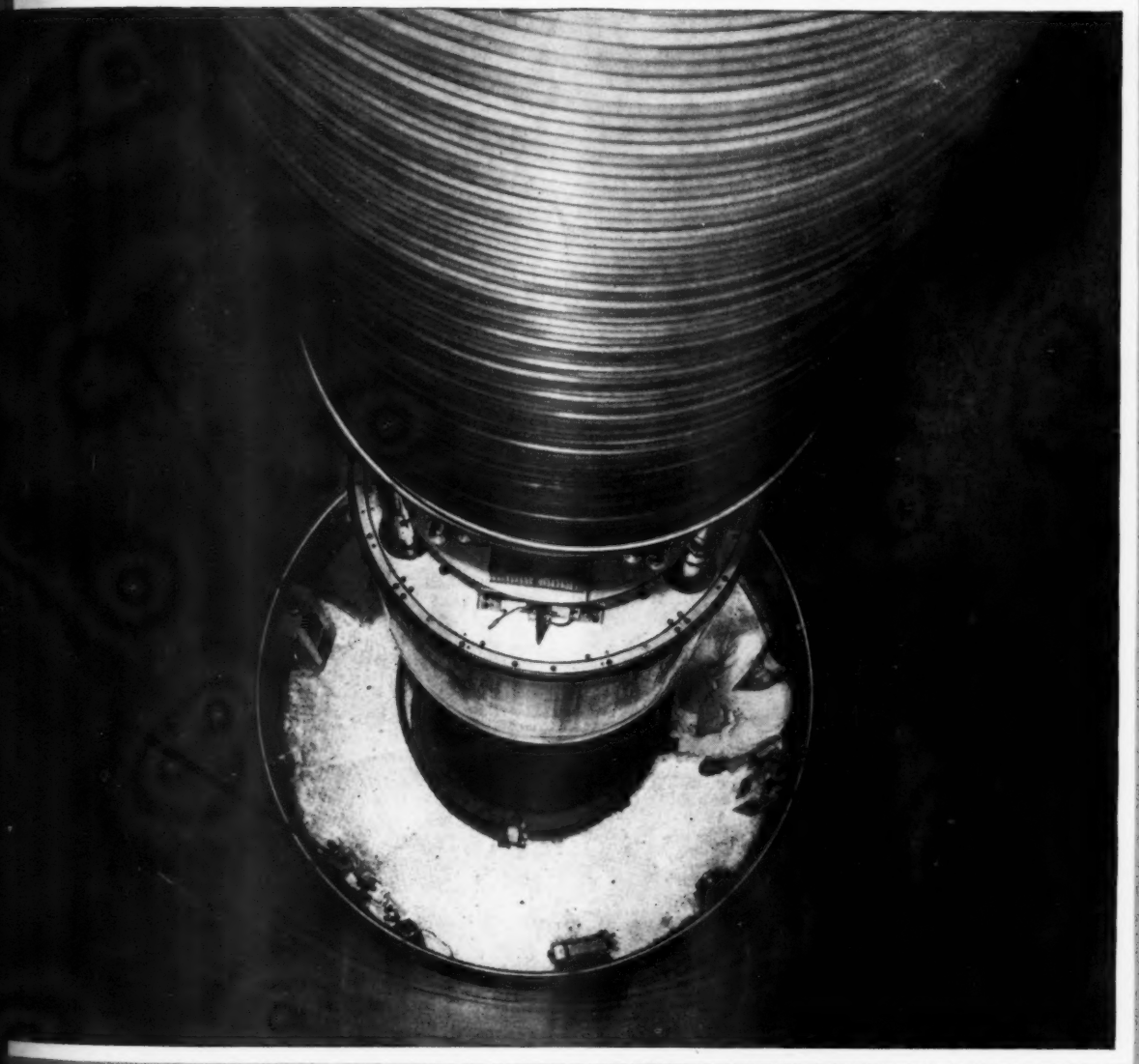
ARTMENT OF TECHNOLOGY
AND ERIE COUNTY PUBLIC LIBRARY

JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

VOLUME 5 NO. 56 AUGUST 1959



VOLUME 5 NUMBER FIFTY-SIX AUGUST 1959

JOURNAL OF THE INSTITUTION OF ELECTRICAL ENGINEERS

SAVOY PLACE LONDON W.C.2 *Telephone* COVENT GARDEN 1871 *Telegrams* VOLTAMPERE PHONE LONDON

PUBLISHED MONTHLY PRICE SEVEN SHILLINGS ANNUAL SUBSCRIPTION TWO POUNDS

Contents

415 **Army communication engineering**

416 **B.B.C. television and v.h.f. sound coverage**

417 **Modern ferromagnetic materials**
by PROF. F. BRAILSFORD, PH.D., B.SC.(ENG.), WH.SC., MEMBER

424 **Electronics in hospital equipment**

425 **Particle work at Aldermaston**

426 **Concentration of advanced courses**

426 **Electronics and National Certificates**

427 **Annual General Meeting of The Institution, 1959**

431 **Annual Report for 1958–59**

457 **Electronic instruments in space-research vehicles**
by R. L. F. BOYD, PH.D., ASSOCIATE MEMBER

463 **Television film by transatlantic cable**

464 **A review of the *Proceedings*, Parts A and B**
(details are given in the adjoining column)

470 **Correspondence**

473 **Obituary**

476 **Papers and monographs published individually this month**
(details are given in the adjoining column)

477 **Technical publications**

477 **Forthcoming events**

478 **Some recent books**

482 **Library accessions**

483 **Elections and transfers**

484 **Announcements to members**

487 **Special General Meeting, 18th August 1959**

487 **British Nuclear Energy Conference**

487 **Contents of the current issues of the *Proceedings***

488 **Bulletin of the Sections**

492 **News from the Centres**

494 **News from abroad**

495 **Officers of The Institution**

BACK COVER **Index of advertisers**

464 A review of the *Proceedings*, Parts A and B

Supplies to power-station auxiliaries	D. A. Dewison
Representation by electrolytic tank	D. Chandra
Controlled thermonuclear reaction	D. W. Fry
Arcs in transverse magnetic field at atmospheric pressure	P. E. Secker and A. E. Guile
Starting of single-phase induction motors	C. S. Jha and A. R. Daniels
Frozen-mercury technique for casting waveguide parts	H. H. Scholefield, H. H. H. Green and R. E. Gossett
Analogue computer for power changes	K. W. Wardrop
Reactance of surface supporting surface waves	K. P. Sharma

476 Papers and monographs published individually this month

PAPERS

Frequency variations of quartz oscillators compared with N.P.L. caesium standard	L. Essen, J. V. L. Parry and J. McA. Steele
Formulae of electromagnetism in the M.K.S. system	P. Vigoureux
Travelling-wave parametric amplifier	A. L. Cullen

MONOGRAPHS

Stability of synchronous machines	A. S. Aldred and G. Shackshaft
Analogue treatment of eddy-current problems	J. Roberts
Forces on magnetized iron parts	C. J. Carpenter

EXPLANATION

WE regret the late delivery of this number of the *Journal* which is due to the after-effects of the stoppage in the British printing industry. It is planned to regain the normal delivery schedule in a month or so

Proton's view

THE cover picture this month shows not the 'wall of death' but the inside of the 45 ft-high pressure vessel surrounding one of the highest-energy electrostatic accelerators in the world. With this new British-built 12 MeV tandem machine producing a very fast jet of protons the Atomic Weapons Research Establishment at Aldermaston is equipped to examine precisely the structure of heavy nuclei such as those of uranium. A brief survey of this and other apparatus housed there, including spectrographs under construction. appears on p. 425

Secretary W. K. BRASHER, C.B.E., M.A., M.I.E.E. *Editor* W. G. ASKEW, M.C.

© 1959: The Institution of Electrical Engineers

Advertising Office TERMINAL HOUSE, GROSVENOR GARDENS, LONDON S.W.1 *Telephone* SLOANE 7266 *Telegrams* INDULICITY, SOWEST LONDON

The Institution is not as a body responsible for the opinions expressed in the *Journal* unless it is stated that an article or a letter officially represents the Council's views

JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

SAVOY PLACE LONDON W.C.2 VOLUME 5 NUMBER 56 AUGUST 1959

ARMY COMMUNICATION ENGINEERING

THE British Army has to be trained and prepared for all types of warfare, ranging from internal-security action to a global war. The former may take place in any part of the world and vary from minor excursions such as those in the Arabian Peninsula to protracted operations such as in Malaya. In a global war one must consider that nuclear weapons will be used by both sides.

In a future major war, for which the Army must prepare, conditions will be very different from those which prevailed at the end of the 1939–45 War. Forces are likely to move with greater speed; distances between headquarters will probably be much longer; intervening ground may well be impassable to the movement of men or vehicles. It is in these far more difficult circumstances that communication will be vital for command and control in the battlefield.

In the Second World War extensive line-communication systems were established, use being made of carrier equipment to provide numbers of speech circuits and of voice-frequency telegraph equipment to produce the teleprinter circuits. Although it is most unlikely that the conditions in another war will permit the formation of large line-communication systems there will always be a need for some form of field cable, if only for local lines. It may however have to be laid by new methods such as from the air, possibly from non-piloted machines.

For radiotelephony, frequency-modulated sets operating in the v.h.f. band now provide the main means of communication between mobile forces, extending down to tank and man-pack sets. At the other end of the scale the Army employs high-frequency radio both for the battlefield and for inter-theatre communication, phase modulation and single sideband being used.

The British Army, with its wireless set No. 10, was a pioneer in the field of radio relay. This set operated in the s.h.f. band and provided eight speech channels with time-division multiplex and pulse-width modulation. One of its most successful uses was during the advance in Western Europe in 1944–45 where it enabled communication to be maintained between Field-Marshal Montgomery's tactical headquarters and main headquarters 21 Army Group.

In the Army now there are radio-relay equipments in the v.h.f., u.h.f. and s.h.f. bands, and their use will increase. Tropospheric scatter is already under consideration for military purposes in the United States and in Europe. Although it has not so far been adopted by the British Army its possibilities are being investigated, and it may well constitute yet another means of communication in war.

The employment of nuclear weapons presents its own particular communication requirements. The commander must have speedy information of enemy dispositions to enable him to select suitable targets; equally fast and reliable communication channels are needed for the transmission of the necessary fire orders to the appropriate weapons. The tempo of a future war is likely to be such that it will be very difficult for staff officers, who serve their commanders by collecting and collating information and working out the details of operations and logistics, to analyse the information and act fast enough. They will have to be helped by automatic data-processing equipment which can perform many of their tasks for them.

Progress during the 1939–45 War was most spectacular in the radar field. In the Army, radar equipment is now an established tool of the Royal Artillery, and application of the radar principle for military purposes is continually increasing. The guided missile with or without a nuclear warhead is becoming a standard Army weapon, and the missile itself and its guidance and control systems make considerable use of the devices of electrical engineering.

The use of electricity to provide power and its application to transport are obvious but no less vital to an army in battle. In fact a complete communication system can be jeopardized by the failure of a generating set at a

nodal point. On the electrical side there will be set up in war a comprehensive repair organization, operated by the Royal Electrical and Mechanical Engineers, ranging from large static workshops to small mobile repair detachments working well up in the combat zone.

Within the Army the electrical engineer plays a vital part which will increase in importance now that science and engineering are being applied more and more to military projects. Engineers are required during the development stages of equipment; they are needed to ensure that the apparatus is set up and used to the best advantage; they are concerned with the maintenance aspect.

In many of these roles the electrical engineer in the Forces has a more difficult task than his civilian counterpart. His equipment must be developed to meet more stringent requirements of size, weight, ruggedness and operational environment; communication systems are rarely established as permanent installations, and the unforeseen emergency is the order of the day; maintenance must take place in far-from-ideal conditions.

Between the two World Wars the Army depended on the General Post Office and other civilian organizations to supply the reserve of trained communication engineers, and many Post Office engineers performed notable work in a military capacity. In another war the Army will not be able to call on civilian sources for its trained engineers to anything like the same extent.

The electrical engineer in the Army must have a sound knowledge and experience in his subject which covers the civilian field as well as the military field; and he must keep himself up to date. The Institution provides the common ground for the military electrical engineer to meet his opposite number, and the discussions and papers enable him to keep abreast of progress. Many Army officers, notably in the Royal Corps of Signals and in the Royal Electrical and Mechanical Engineers, are members of The Institution.

All R.E.M.E. regular officers attend a degree course either at Cambridge or at the Royal Military College of Science, and many will therefore obtain their qualifications by this method. Only a proportion of Royal Signals regular officers attend degree courses; others attend a telecommunication engineering course at the School of Signals. Special arrangements have been made for the satisfactory completion of this course to count as exemption from Parts II and III of the Institution Examination.

About 9% of regular R.E.M.E. officers are Chartered Electrical Engineers; the corresponding figure for Royal Signals officers is about 5%. This membership is beneficial to the Army as a whole and to the profession. Interchange of ideas between military and civilian electrical engineers is of value. This interchange may be facilitated by the civilian engineer's appreciation of the Army's problems. It is hoped that this Foreword will be of some assistance in this respect.

B.B.C. television and v.h.f. sound coverage

THE Postmaster-General has approved in principle the first stage of the B.B.C.'s plan for extending and improving the coverage of the television service and of the three sound services on v.h.f. by building low-power satellite stations in various parts of the country.

By the end of 1959 there will be 23 B.B.C. television stations in operation serving about 98·7% of the population and 21 v.h.f. sound-broadcasting stations covering about 96·4%.

Bringing television and v.h.f. broadcasting to the remaining areas and improving reception in those which suffer at times from severe interference from foreign stations are difficult problems. Most of the areas concerned are sparsely populated and many are mountainous. For television it is not practicable to build high-power stations to serve them all because only five channels, all in Band I, are available to the B.B.C.; and these are already occupied by high- and medium-power stations. There is a similar problem in extending the coverage of the v.h.f. sound network.

A number of low-power satellite stations are therefore planned both for television and for v.h.f. sound broadcasting, and 14 television and 10 v.h.f. sound stations will be built during the next three years. Most will be 'translators', similar in principle to the B.B.C.'s television translator at Folkestone which has been working successfully since July 1958. They will be designed to work unattended: each transmitter will pick up signals from an existing B.B.C. station and retransmit them on a different channel for local reception.

The towns and districts to be covered are: Berwick upon Tweed, Fort William, Loch Leven, Oban, the Galashiels and Llandrindod Wells areas, and West Cornwall (television and three v.h.f. sound programmes); the Oxford/Berkshire area (television for Oxford and four v.h.f. programmes for a wider district); Sheffield, Skegness, and the Barrow/Lancaster, Enniskillen, Ipswich and Pembroke/Milford Haven areas (television only); and Les Platons and Londonderry (v.h.f. sound only, on the same sites as existing television stations).

It is hoped to provide further stations at a later stage in other parts of the country where they are most needed.

An electrical engineering review

621.318.122/.132 MODERN FERROMAGNETIC MATERIALS

After a note of some of the more important characteristics of ferromagnetic materials, a brief account is given of developments in materials of greatest practical interest. These include silicon–iron, nickel–iron and permanent-magnet alloys. Ferrites and the phenomenon of ferrimagnetism are discussed. The author is Professor of Electrical Engineering, University College London.

Prof. F. BRAILSFORD, PH.D., B.SC.(ENG), WH.SC., MEMBER

THE generation and distribution of electricity for use in the factory and the home are economically possible only because nature provides a cheap and plentiful element, namely iron, with the extraordinary property known as ferromagnetism. This phenomenon occurs to a lesser degree in cobalt and nickel, which are more expensive, and also, though weakly, in the rare element gadolinium; in addition, some alloys and chemical compounds composed entirely of non-ferromagnetic elements are strongly magnetic.

But iron is, in this connection, the most important material, without the magnetic properties of which the course of technological development and scientific discovery in the past century would have been immeasurably different.

Because iron is ferromagnetic the material may have induced in it a high magnetic flux density for a relatively small applied magnetizing force. This property enables generators, motors, transformers and other electrical equipment to be built in a compact and efficient form.

The magnetization curve

The important magnetic characteristics of a ferromagnetic material are illustrated in Fig. 1 for ordinary polycrystalline dynamo-iron sheet. After allowing for a small percentage of silicon and unavoidable impurities, this may contain about 99·6% iron.

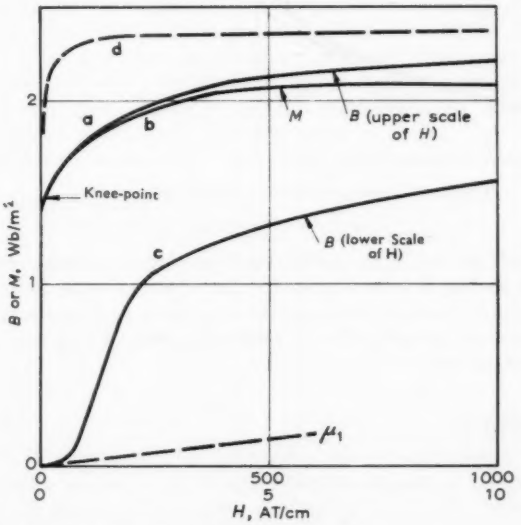
Curves **a** and **c** show the relation between magnetic flux density B and the magnetizing field strength H. The intensity of magnetization* M falls a little below B, as shown by curve **b**. For unalloyed iron a flux density of 1·5 Wb/m² (15000 gauss) is obtainable for a magnetizing field of about 10 AT/cm (about 12·5 oersteds). To raise B or M much above this knee-point requires a greatly increased applied field, and to bring M near magnetic saturation a field strength of about 500 AT/cm is necessary.

The design of rotating machines and of magnetic cores for power transformers is limited by the shape and by the numerical values of the magnetization curve. The total flux in a motor armature is restricted by magnetic saturation in the teeth, and the working peak value B_{max} in a transformer core is, to avoid excessive magnetizing current, limited by the position of the knee-point. This point is, in fact, a little lower for hot-rolled silicon–iron transformer sheet than for iron (about 1·35 Wb/m²).

Modern developments have enabled the knee-point for transformer steel to be raised considerably. The saturation intensity can also be raised by alloying the iron with cobalt, but the widespread application of cobalt–iron in heavy equipment is limited by cost. Curve **d** shows the magnetization of an alloy containing equal quantities of iron and cobalt and with 2% vanadium added to improve the mechanical properties.

The curve near the origin

The lower part of curve **c** in Fig. 1 is of more interest in light-current or high-frequency applications where

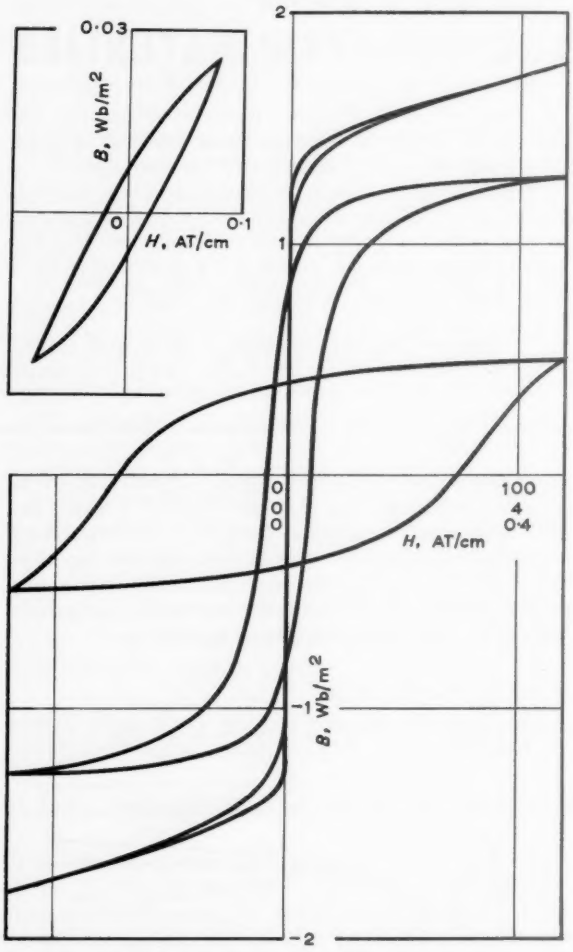


1 *Magnetization curves of dynamo iron*

Curve **d** is the M/H magnetization curve (upper scale of H) obtainable with cobalt–iron (49% Co, 49% Fe, 2% V)

* In the M.K.S. rationalized system of units $B = \mu_0 H + M$ where $\mu_0 = 4\pi \times 10^{-7}$ henry/m

the applied fields are small or where the flux density is restricted to low values. In these cases the important parameter is the initial permeability μ_1, determined by the slope of the magnetization curve at the origin. Iron



2 *Hysteresis loops of silicon–iron transformer sheet*

itself is not very useful since its initial relative permeability is low—about 250 for dynamo iron. In this respect the nickel–iron alloys are greatly superior, initial relative permeabilities of 10000 and more being readily obtainable.

Hysteresis

Hysteresis, the effect whereby the flux density B lags behind a changing applied field H, is a familiar characteristic of ferromagnetics in general. The shape of the hysteresis loop for a given material under alternating magnetization depends, as Fig. 2 shows for samples of transformer iron, on the extent of the flux-density swing.

This characteristic may be either undesirable or useful, depending on the particular application. In alternating conditions, as in a transformer core or in the stator of an alternator or a motor armature, a loss of energy, which is proportional to the area of the hysteresis loop, appears as heat in the material. This is a waste of energy which adds also to the problem of cooling the equipment. Hence, in these applications the narrowest possible hysteresis loop is required.

On the other hand, in the permanent-magnet materials, where the usual requirement is to maintain a total magnetic flux in an air-gap of given dimensions with the minimum weight of material, the greatest possible hysteresis effect is required. Whereas in a transformer iron the coercivity* may be less than 0·2AT/cm, for permanent-magnet materials this may be 500AT/cm or more.

The hysteresis effect, with a hysteresis loop of suitable shape, is also important in the operation of small magnetic cores used for storing information in the magnetic-memory matrices of digital computers.

Limitations at high frequencies

One of the great disadvantages of the ferromagnetic metals is their high electrical conductivity. This limits their application at higher frequencies because of induced eddy currents, which cause a poor distribution of flux across the section of the metal and energy losses. These difficulties are minimized, as is well known, by employing thin laminations—sometimes less than 0·001 in. thick.

The eddy currents can also be reduced for iron by adding silicon (or aluminium). For example, transformer iron containing 4% silicon has an electrical resistivity about four times that of unalloyed dynamo iron, the eddy-current losses being proportionately reduced; and nickel–iron alloys are available having somewhat greater resistivities.

However, within the last 20 years non-metallic magnetic materials known as ferrites have been synthetically produced which are, in fact, only semiconductors. Unfortunately, these materials have a magnetic saturation which is, in general, less than one-quarter that of iron, but they have the outstanding advantage of an electrical resistivity 10^6–10^9 times as high as that of the metals. Unlaminated ferrite cores can therefore be used up to the highest frequencies with negligible eddy-current losses.

Crystalline structure of ferromagnetic materials

In the past few decades new magnetic materials have been produced and old ones greatly improved; and this has occurred in parallel with notable advances in the theory of ferromagnetism, on the basis of which the processes of magnetization can be understood and the properties of new materials explained.

* Coercivity may be defined as the reverse magnetic field strength required to reduce the flux density in a material to zero after it has been magnetized to saturation in the forward direction

Investigations on large single crystals of ferromagnetic materials show that these are, except in some cases, highly directional in their magnetic properties. Fig. 3 shows the magnetization curves of single crystals of silicon–iron. The iron atoms, each of which may be regarded as a small permanent magnet, are arranged on a body-centred-cubic crystal lattice. Any cube edge is found to be a direction of high permeability with a knee-point approaching the saturation value, as shown by the curves A. Other measurements show that in this direction the hysteresis effect is small.

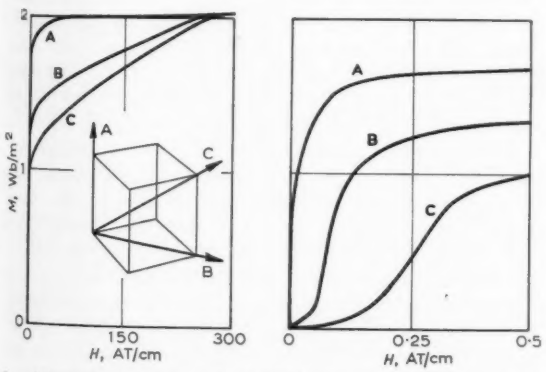
Fig. 4, a further example of comparatively recent experimental work, shows the pattern observed under a microscope on the polished surface of a single crystal of silicon–iron which has been wetted by a soap solution containing a finely-divided magnetic powder. The powder collects in lines on the surface and outlines the underlying magnetic structure of the material.

Domains

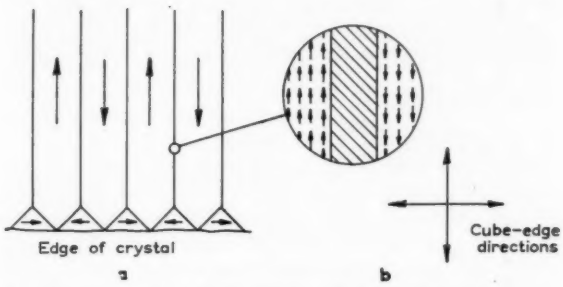
From this and a mass of other evidence it is now known that ferromagnetic materials are made up of magnetically saturated 'domains'. In Fig. 4a each domain where it meets the surface is bounded by the straight lines, and at room temperature nearly all the atomic magnets of which the domain is composed point in one direction, thus producing spontaneous magnetic saturation in the direction of the arrows. The domains are believed to be thin laminae, about 0·1 mm thick in this example, like the pages of a book, Fig. 4a being an edge-on view of them.

Between adjacent domains is a boundary wall, several hundred atom-layers thick, across which there is a gradual transition of the direction of the atomic axes from one domain to the other. This wall is shown shaded in the circle in Fig. 4b.

Structures similar to this will occur in all the crystals of a polycrystalline specimen, although the surface patterns may be more complicated. The existence of the self-saturated domains and the fact that the boundaries between them are relatively easily moved by an applied magnetic field account for the extraordinary magnetic properties of ferromagnetic materials—in sharp contrast to non-ferromagnetic substances, in which these domains do not form.



3 *Magnetization curves for 3·85%-silicon–iron single crystals at high and low field strengths, showing strong directional properties*



4 *Ferromagnetic domain structure in a silicon–iron crystal*
a Pattern observed on crystal surface, showing thin plate-like domains about 0·1 mm thick
b Boundary layer of finite thickness between neighbouring domains

SILICON–IRON ALLOYS

Until the beginning of this century the material used for transformer cores and motor armatures consisted of insulated laminations of unalloyed iron. It was discovered, however, that the addition of silicon to iron reduced not only the eddy-current component of iron loss, as already mentioned, but the hysteresis component also, and from about 1906 onwards silicon–iron came into use for transformer cores. This material is still popular, a gradual improvement in quality having taken place over the years until, more recently, a major development resulting in the production of grain-oriented silicon–iron has occurred.

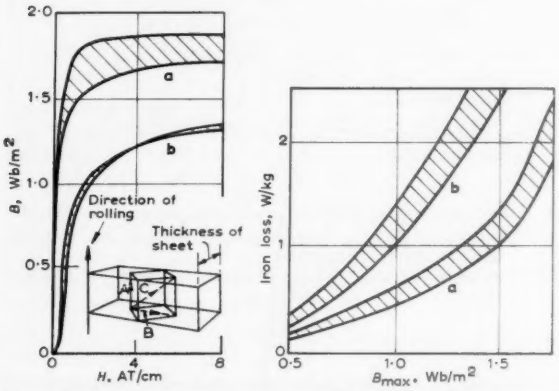
Grain-orientation

In the grain-oriented material, which contains 3–3½% silicon, the grains or crystals of the polycrystalline sheet have been induced to take up a particular alignment in the sheet. The manufacturing process includes a very heavy cold-reduction in thickness in the mill, followed by a suitable high-temperature heat-treatment. The preferred alignment of the crystals is shown in Fig. 5, with a cube-edge direction A parallel to the direction of rolling and a cube-face diagonal direction B perpendicular to this in the plane of the sheet.

The polycrystalline material thus has directional magnetic properties similar to those shown for a single crystal in Fig. 3, although less well defined because some spread about the preferred position occurs. In the rolling direction the grain-oriented material has a magnetization

curve with a high knee-point and a relatively low hysteresis loss.

Hot-rolled silicon–iron transformer material does not have these advantages, since the crystals in this case are arranged in a more or less random fashion, and the magnetic properties in any direction in the sheet are an approximate average for all directions of a single crystal.



5 *Comparison between two commercially available transformer materials*

a Cold-reduced grain-oriented 3¼%-silicon–iron
b Hot-rolled 4%-silicon–iron
Notice the greatly improved magnetization curve and lower iron loss of **a**
Material 0·014 in. thick; frequency 50 c/s

Fig. 5 compares the present commercially available transformer materials. The hatched areas **a** embrace the magnetization curves and iron-loss curves for grain-oriented 3¼%-silicon–iron in the rolling direction, and those marked **b** the corresponding curves for hot-rolled 4%-silicon–iron.

Small transformer cores may be made of continuous grain-oriented strip so that full use is made of the best direction of the material. The strip-wound construction is not practicable, however, for large cores, which are built up with overlapping laminations in the conventional manner: with grain-oriented material the fullest use is not made of the best direction in the sheet, since at the corners between legs and yokes the flux must follow all directions, including the unfavourable directions of low permeability and high loss.

Improved type of preferred orientation

The type of preferred orientation shown in Fig. 5 is, indeed, not the best possible. If the crystals were induced to line up with cube faces parallel to the surface, a cube-edge direction such as A could be along the rolling direction and also across the sheet, and the worst direction C would be eliminated from the plane of the sheet. The two types of preferred orientation are illustrated in Fig. 6 in relation to the variation of hysteresis loss with direction.

This new type of grain-oriented material should, when it becomes commercially available, contribute to a reduction of stray loss in built-up transformer cores and also be a more suitable material for use in turbo-generators and other rotating machines. Figs. 7 and 8 show examples of present applications of grain-oriented silicon–iron.

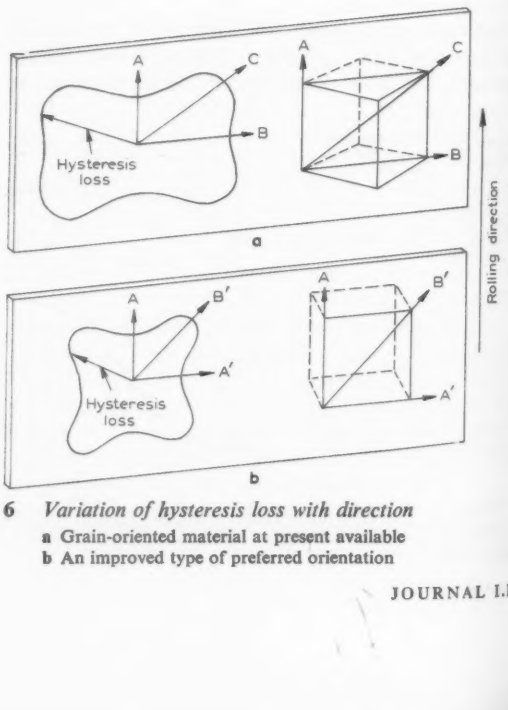
NICKEL–IRON ALLOYS

When nickel and iron are alloyed together in different proportions a remarkable series of alloys is obtained forming the basis of an important group of useful magnetic materials. The way in which various properties change with the nickel content is illustrated in Fig. 9.

The curves for M_s show that when the nickel content is a little over 25% the alloys tend to be non-ferromagnetic at room temperature, although alloys of such composition are extremely slow in response to heat-treatment. For lower percentages of nickel the alloys have the same body-centred-cubic crystal structure as iron and do not appear to be particularly noteworthy. When the nickel content is greater than about 30% the structure is face-centred cubic, the same as for nickel itself, and these are the alloys of magnetic interest.

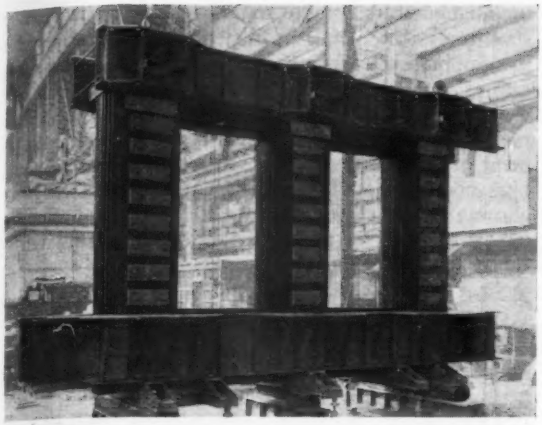
The temperature above which the alloys cease to be ferromagnetic, i.e. the magnetic change-point or Curie temperature, is shown in Fig. 9 for the whole range.

The electrical resistivity reaches a maximum when the nickel content is about 36%, and M_s is a maximum for about 50% nickel: Rhometal is a commercial material which takes advantage of the former characteristic and Radiometal of the latter. The alloy containing 50% Ni, 50% Fe is also produced in thin strip in grain-oriented form, the preferred orientation being of the kind shown in Fig. 6b.



6 *Variation of hysteresis loss with direction*

a Grain-oriented material at present available
b An improved type of preferred orientation



7 *Example of a 3-phase transformer core of built-up construction of grain-oriented silicon–iron for 75 MVA*

H.C.R. alloy is a commercial material of this kind having similar magnetic properties both along and at right angles to the rolling direction, with a relatively sharp knee-point to the magnetization curves and a rectangular hysteresis loop. These are useful characteristics in the core materials of magnetic amplifiers and other equipment.

Exceptionally high permeability

A special feature of the nickel–iron alloys is their very high magnetic permeability in weak fields. For the alloys already mentioned, the initial permeability may be five to ten times greater than that for dynamo iron. However, the most outstanding alloys in this respect are obtained when the nickel content is about 75% or a little over.

Fig. 9b shows typical values of the maximum relative permeability of the complete range of straight nickel–iron alloys. At 78·5% nickel the curve has a remarkable peak: this particular alloy is known as Permalloy A. Commercial versions have other constituents added to raise the electrical resistivity and to make the heat-treatment conditions less critical. Mumetal is a well known example, having an initial relative permeability of 20000–30000 and a maximum of about 90000.

A typical relation between relative permeability and flux density for Mumetal is given as curve **b** in the left-hand part of Fig. 10, and a hysteresis loop for $B_{max} = 0{\cdot}5 \text{Wb/m}^2$ (5000 gauss) is shown in the right-hand part.

When great care is taken with the purification and heat-treatment of these alloys a vast improvement in magnetic properties is obtainable. Curves **a** in Fig. 10 exemplify this for Supermalloy in the form of 0·014in. sheet; this has an initial relative permeability of about 120000 and a maximum relative permeability of about 900000. At the same time there is a very small hysteresis loss, indicated by the hysteresis loop in Fig. 10. Supermumetal has properties intermediate between those shown for Mumetal and Supermalloy.

PERMANENT-MAGNET MATERIALS

The function of a permanent magnet is, usually, to maintain a desired total magnetic flux in an air-gap of given volume and proportions. The volume of the magnet to do this depends on the demagnetization characteristic of the magnet material.

If the closed-ring magnet shown at **g** in Fig. 11 is magnetized circumferentially to saturation and the magnetizing force removed, a flux density B_r remains in the material. On applying an increasing magnetizing force H in the reverse direction the flux density B in the ring falls along a demagnetization curve such as RPC, becoming zero when H reaches the value H_c. H_c is the coercivity and B_r the retentivity of the material. We may also plot the product BH against B for any point on the demagnetization curve; this product will be a maximum $(BH)_{max}$ for some point such as P′ in Fig. 11.

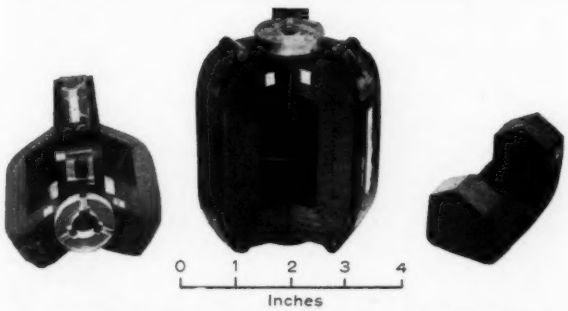
The closed ring shown at **g** carrying the remanent flux density B_r would, however, also be partially demagnetized without using an externally applied field if, instead, an air-gap were introduced into the ring as shown at **h**. The flux density in the ring would then fall from B_r to some value B_w corresponding to a point P on the demagnetization curve. Free poles would appear on the pole faces, and the magnetomotive force between them would act on the one hand as a demagnetizing force on the magnet material and on the other to produce a useful magnetic flux in the air-gap.

If P has been reached this m.m.f. is $H_w l$, where l is the mean length of the magnetic path in the magnet material and H_w the field strength read off the curve at P. It is in fact readily shown that, if the required total air-gap flux is Φ in an air-gap of reluctance R, the volume of the permanent magnet is given by:

$$V = \frac{KR\Phi^2}{B_w H_w}$$

where K is a factor taking account of magnetic leakage.

If the magnet is designed to work at the point P′ in Fig. 11, the volume of magnet material is a minimum for this particular demagnetization characteristic. The

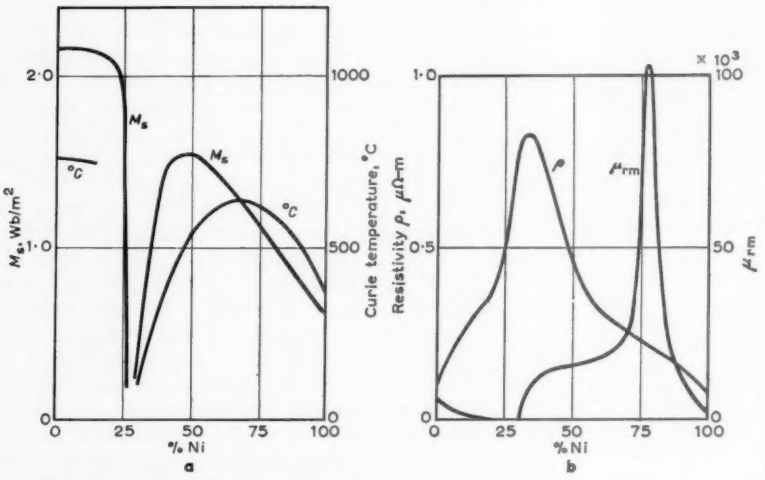


8 *Three-phase-wound core to give symmetrical flux distribution: grain-oriented silicon–iron*

quantity $(BH)_{max}$, together with B_r and H_c, is therefore a measure of the quality of a permanent-magnet material, and the saturation hysteresis loop in this quadrant should in general be as fat and as full as possible.

Martensitic steels

The earlier permanent magnets were simple carbon steels, with carbon up to about 1½%, quenched from a high temperature in oil or water to produce a martenistic structure in the metal. In this condition iron carbide is in a fine state of arrested precipitation, introducing strain centres throughout the metal on an atomic scale. As well as producing great mechanical hardness, the presence of the internal strains restricts the free movement of domain boundaries, so resulting in a relatively high coercivity and hysteresis. Additions of tungsten, chromium and cobalt raise the coercivity, and examples of these martensitic steels are given in Fig. 11.



9 *Characteristics of nickel–iron alloys*
a Variation of saturation intensity M_s and Curie temperature with nickel content
b Variation of resistivity ρ and maximum relative permeability μ_{rm} with nickel content

Iron–nickel–aluminium alloys

However, the permanent-magnet materials most extensively used today are not steels at all, since they do not depend for their properties on the presence of carbon. They are the diffusion-hardening alloys based upon the ternary iron–nickel–aluminium. Alloys with a composition approximating to the formula Fe_2NiAl when suitably heat-treated have a $(BH)_{max}$ value about 30% greater than, and a coercivity about double, that of the best cobalt steel.

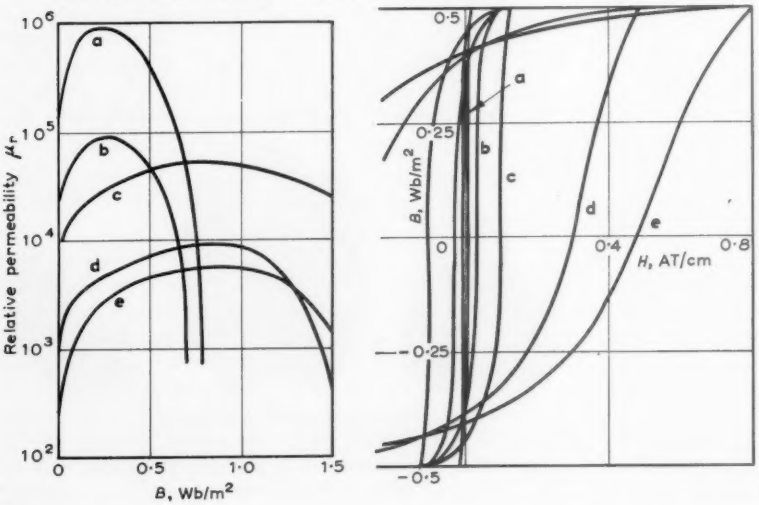
The explanation of the high coercivities in terms of strain-impeded domain-boundary movements becomes increasingly improbable, because when the strain theory is applied the associated internal stresses become unreasonably high—about 400 tons/in.² in the alloy just mentioned. Substantial further improvements have been obtained by including cobalt and copper in its composition: Alnico (curve **c** in Fig. 11) is an example.

Strongly directional magnetic properties can be induced in these alloys, when of appropriate chemical composition, if they are allowed to cool from a high temperature, of the order of 1300°C, at a controlled rate in a steady magnetic field of several thousand AT/cm. Ticonal, Alcomax and Alnico V are examples. A vast improvement in the demagnetization characteristic measured in the direction selected during the heat-treatment occurs at the expense of that in the perpendicular directions; for example, B_r in the working direction may be more than double the value laterally, and H_c is also much greater.

Curve **d** in Fig. 11 is the demagnetization curve for Alcomax III.

These materials are produced by casting, and it is found that if elongated or

10 *Comparison of permeability and hysteresis of various materials*
All materials 0·014 in. thick
a Supermalloy (79% Ni, 5% Mo, 0·5% Mn, 15·5% Fe)
b Mumetal (75% Ni, 4% Mo, 5% Cu, 16% Fe)
c Grain-oriented silicon–iron in rolling direction (about 3¼% Si)
d Hot-rolled 4%-silicon–iron **e** Hot-rolled dynamo iron



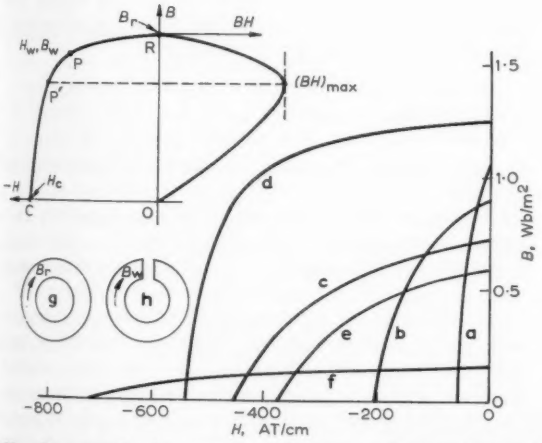
'columnar' crystals are grown in the casting in the direction of subsequent magnetization a further improvement in the demagnetization characteristic is obtained. This is not an easy production process, but semicolumnar Alcomax is commercially obtainable.

Soft-iron powder

Surprisingly good permanent magnets can be made from soft-iron powder. A single-crystal particle of iron will, in general, comprise a number of domains. However, there are good theoretical grounds for the belief that if the particle is smaller than about 10^{-5}cm in diameter it can only be a single domain, and so there is no internal domain boundary.

If the particle is elongated, the saturation magnetization in it will lie lengthwise, and a high magnetic field strength will be required to reverse the magnetization. It can be shown that a material made of particles of iron below the critical size and departing from the spherical form by only about 10% would have a coercivity of about 350AT/cm. Theoretically, the use of aligned needle-shaped iron particles of less than critical size should produce a directional magnet with a coercivity of 8500AT/cm. Micropowder magnets are commercially available.

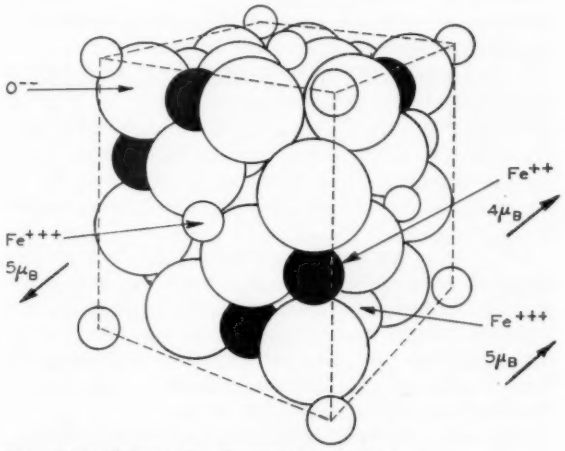
A demagnetization curve is shown in Fig. 11, curve **e**, for an iron-powder magnet. Curve **f** shows the characteristic of a permanent-magnet material made from oxide powders; this type of material is characterized by a very high coercivity and relatively low retentivity. Because of the shape of the demagnetization curve, oxide magnets, once magnetized, are not easily demagnetized.



11 *Demagnetization curves of some permanent-magnet materials*

a Tungsten steel (6% W, 0·9% C)
b Cobalt steel (35% Co, 3·5% Cr, 3% W, 1% C)
c Alnico (10% Al, 18% Ni, 12% Co, 6% Cu)
d Alcomax III (8% Al, 13·5% Ni, 24·5% Co, 3% Cu, 1% Nb)
e Iron powder
f Vectolite (30% Fe_2O_3, 44% Fe_3O_4, 26% Co_2O_3)
g Closed-ring magnet **h** Ring magnet with air-gap

Fine magnetic powders may be compacted to form permanent magnets if the particles are below the critical size for domain-boundary formation. However, if the particles are greater than the critical size and are compressed together with a suitable insulating binder, a low-loss material of high electrical resistivity is obtained which has the particular advantage of low eddy currents.



12 *Crystal structure of magnetite (Fe_3O_4)*
Large spheres represent negative oxygen ions
The resultant spontaneous magnetization is due to the divalent positive iron ions shown by the black spheres

Iron-dust cores are in fact available as low-loss materials for radio and other high-frequency purposes even up to 300Mc/s. However, the relatively new class of magnetic materials known as ferrites can be used as magnetic cores in high-frequency work without powdering or laminating because of their exceptionally high electrical resistivities.

THE FERRITES

The mineral magnetite Fe_3O_4 is a natural ferrite which in its impure state has a coercivity of about 16AT/cm—the same as that of a hard 0·5%-carbon steel. This is the material of the lodestone, which has well known permanent-magnet properties. When it is purified the hysteresis effect is reduced and permeability increased, an initial relative permeability of about 70 being obtainable. The magnetically useful ferrites, however, are synthetic oxides, based on Fe_3O_4 in which some of the iron atoms are replaced by the atoms of other elements. They are hard, ceramic, crystalline substances.

The crystal structure of Fe_3O_4 is shown in Fig. 12. The volume within the cube outlined by the broken lines corresponds to eight molecules of Fe_3O_4. The large spheres represent negative oxygen ions, negative because each oxygen atom has gained two electrons from the iron atoms. The smaller white spheres represent positive iron ions, each of which has lost three electrons, while the

black spheres are divalent iron ions, each having given up two electrons.

From well established ideas the magnetic moments of the ions in the crystal are as follows: the oxygen ions have zero resultant magnetic moment; the trivalent iron ions each have a magnetic moment of 5 units (5 Bohr magnetons $= 5\mu_B$); and the divalent iron ions have a moment of 4 units each.

Ferrimagnetism

In an iron crystal a domain structure exists, as already mentioned, in which the atomic magnetic axes of the iron atoms are aligned to produce magnetic saturation in a cube-edge crystal direction. A domain structure with parallel alignment of the atomic axes also occurs for the crystal in Fig. 12 but with two differences from metallic iron.

First the direction of the axes is parallel to a long-diagonal direction of the cube; secondly, and unfortunately, one of the trivalent iron-ion magnets in each molecule points in the opposite direction to the two remaining iron ions. This anti-parallel behaviour means that the magnetic moment per molecule is only 4 units instead of an otherwise possible 14 units.

This condition of two unequal and oppositely pointing systems of parallel magnetic moments is known as 'ferrimagnetism'. The saturation magnetization of the ferrites is low in consequence—for Fe_3O_4 less than one-third that of iron.

Since the trivalent ions cancel each other magnetically the magnetic properties of the ferrite are due to the divalent ions (shaded black in Fig. 12). Materials may be produced artificially in which the divalent iron ions are replaced by divalent ions of another element. If manganese is used a simple manganese ferrite is obtained. Divalent manganese has a magnetic moment of 5 units per atom, and for divalent nickel the value is 2 units; hence the relative magnetic-saturation values of manganese ferrite, Fe_3O_4 and nickel ferrite should be in the ratio 5 : 4 : 2, and experimental observation confirms this.

When the divalent element is changed, not only the saturation value is changed but other magnetic properties also, including the Curie temperature, the magnetostriction and the directional properties of the crystals. Different simple ferrites can be combined to form one homogeneous solid solution, and it is therefore not surprising that a wide variation of magnetic characteristics can be obtained from different combinations.

The useful ferrites are in fact mixtures. There are commercially available manganese–zinc, nickel–zinc and magnesium–manganese ferrites in various grades. These materials already have applications in data-storage systems in computers, in telephony and radio and for special purposes even up into the microwave region of operation.

Summary

Iron and silicon–iron, the nickel–iron alloys, permanent-magnet materials and the ferrites have been discussed, and the magnetic and electrical characteristics of importance in these different types of substance have been commented on. Grain-oriented silicon–iron represents a major development in materials for power plant. There have also been interesting and significant advances in permanent-magnet substances, in the nickel–iron alloys and in the ferrites, materials which have applications in light-current work.

It has been possible in this article to give only the barest outline of some of these fascinating topics. The physical basis of some ferromagnetic and ferrimagnetic phenomena has been briefly mentioned.

Electronics in hospital equipment

In the design of routine hospital apparatus there were signs at the 2nd International hospital equipment and medical services exhibition in London recently that a good deal is being done to bring to doctors, nurses and patients the benefits of techniques familiar to the radio industry, nuclear research laboratories, and industry generally.

Transistors have made their appearance in electrocardiographs, faradic units, heart-pacers, etc., rendering hitherto cumbersome equipment easily portable. A battery-operated cardiograph, for instance, weighing 20lb and containing a plug-in transistorized amplifier can be carried conveniently by visiting doctors and physiotherapists.

The open-heart operation is more frequently performed nowadays, and of course the first and most outstanding development in this field is the artificial heart and lung machine which was designed by a research doctor and a firm of electronic engineers making routine electro-medical and other equipment. Continuous monitoring of the heart's behaviour during and after any operation can now be achieved by displaying the cardiogram on a long-persistence cathode-ray tube.

In an improved electro-encephalograph care has been taken in the lay-out of controls so that changes can be made by touch without the operator having to remove his attention from the patient.

Demonstrating the versatility of the Van de Graaff electrostatic generator is the 2MeV particle accelerator. Three have been installed in British hospitals for some years; they are used *inter alia* for the X-ray treatment of deep-seated tumours. The high output and the precise focusing obtainable permit the short treatment necessary for the patient's comfort without sacrificing the long target-to-skin distance required for minimum skin damage and maximum-depth dose.

Electronic analysis of respiratory gases, ultrasonic cleaning of surgical equipment, cleaning of air by ionization, automatic control of sterilization, staff location, etc.—the applications of electrical engineering are varied and were well represented at the exhibition.

Particle work at Aldermaston

A PARTIAL raising of the security veil at the Atomic Weapons Research Establishment, Aldermaston, reveals a remarkable, possibly unique, collection of apparatus for studying nuclear structure and nuclear reactions.

Although the nuclear physics division of the establishment was set up in 1955 primarily to obtain data for the associated weapons projects, many of its findings from pure research are of great potential importance in other fields, notably in the design of fission reactors.

The machines principally used at Aldermaston for accelerating charged particles are of the electrostatic-generator type in which the energy can be controlled to about 1 part in 5000; and two standard Van de Graaff machines, one accelerating up to 3 MeV the other to 6 MeV, have been in use for some time.

Tandem electrostatic generator

For research on heavier nuclei, however, such as those of uranium, much higher energies are needed—of the order of 10–14 MeV. A recent addition to the A.W.R.E. collection is a 12 MeV 'tandem' electrostatic generator which by utilizing the principle of 'charge-changing' requires an accelerating potential of only 6 MV.

This machine, costing about £200000, was designed and constructed jointly by the A.W.R.E., the A.E.R.E., Harwell, and a large British electrical engineering firm. It was completed during Easter 1959 and has already been used for 10·3 MeV bombarding experiments. A similar machine is installed at Harwell; and a horizontal arrangement based on the same principle, which was designed and built for Atomic Energy of Canada Ltd. by an American firm, went into operation at their Chalk River establishment in January 1959.

Principle of charge-changing

The design of the tandem electrostatic generator depends on the fact that if a neutral hydrogen atom travels slowly (50–100 keV) through a gas, an electron belonging to one of the gas atoms is likely to stick to it, producing a negative hydrogen ion: double-electron capture can similarly convert a positive hydrogen ion to a negative one. Conversely, most of the fast-moving negative hydrogen ions passing through gas at low pressure are stripped of electrons and by double-electron loss are converted to positive hydrogen ions.

The straight cylindrical accelerating tube is earthed at each end, and an electrostatic generator running up the lower half of the tube imposes a potential of up to 6 MV halfway along it. A beam of low-energy negative hydrogen ions from an ion source is injected at one end; and owing to the voltage gradient these ions accelerate towards the halfway point, where, with energies of 6 MeV, they enter a tube containing gas at low pressure, known as the 'stripper'.

Those ions which lose one electron emerge from the stripper as neutral atoms and drift on towards the bottom of the tube without gaining more energy. Ions stripped of two electrons, however, emerge as positive hydrogen ions and are thus further accelerated along the second half of the tube, attaining final energies of 12 MeV.

Besides vastly extending the range of energies and materials which can be examined, the tandem generator has an outstanding advantage over the standard Van de Graaff machine in that its ion source, being at earth potential, can be housed with its elaborate focusing mechanism outside the 45 ft-high pressure vessel which surrounds the accelerating tube.

Neutron spectrometry and 'time of flight'

All three electrostatic generators at Aldermaston can be used as neutron sources by bombarding a target of tritium or deuterium with a beam of accelerated protons or deuterons led through a vacuum tube. The establishment also possesses an 800 keV Cockcroft–Walton machine, with which source strengths of up to $10^{10} \times 14$ MeV-neutrons/sec can be achieved.

Many experiments involve the measurement of a neutron spectrum. Neutrons of known energy are made to induce a nuclear reaction in the specimen under investigation, and the different energies of the neutrons emitted from the reaction can be determined by a 'time of flight' technique. This method is particularly suitable for discriminating between low energies and consists in measuring the time taken for the neutrons to travel a given distance.

Charged-particle spectroscopy

For deriving the energy spectrum of charged particles, the different speeds can be analysed by the degrees of deflection of the particles in a magnetic field. Four large magnets are owned by the nuclear physics division. Two are used in particle spectrometers, one for experiments with the 6 MeV generator and the other, not yet completed, for the 12 MeV tandem. In these, particles of a given energy are focused on a counter, and the variation in energy is observed for alterations of the energizing current. Both magnets are rotatable, and the angular distribution of each component of the spectrum can be determined. The spectrometer for the 12 MeV generator can observe a maximum proton energy of 20 MeV.

The 10·5 MeV proton beam from the tandem accelerator emerging into the air from a thin nickel foil

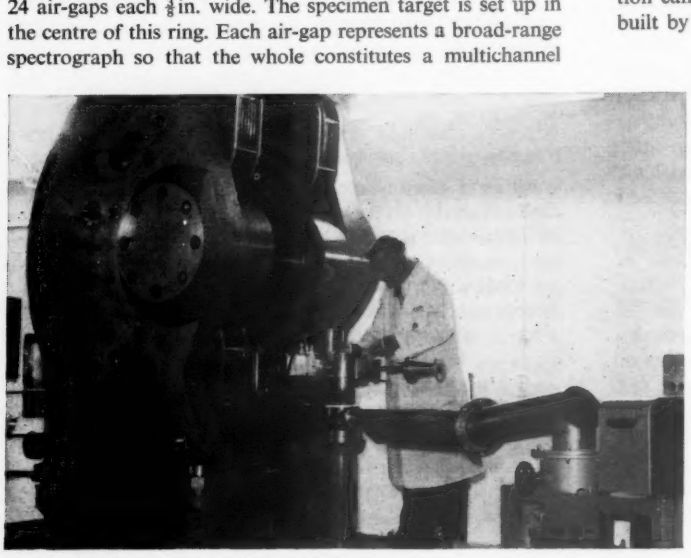
Broad-range spectrographs

The other two magnets are used in broad-range spectrographs in which particles of different energies are brought to different focal points along a nuclear emulsion plate and thus the entire spectrum can be obtained in one exposure. Again, one is used with the 6 MeV Van de Graaff machine and the other, still being built, with the 12 MeV tandem.

The magnet for the latter weighs 13 tons and is in the form of a large ring cut at approximately $7\frac{1}{2}°$ intervals to produce 24 air-gaps each $\frac{3}{8}$ in. wide. The specimen target is set up in the centre of this ring. Each air-gap represents a broad-range spectrograph so that the whole constitutes a multichannel instrument which can determine in one exposure the spectrum and the angular distribution of each component.

The magnetic field of 10000 gauss is stabilized to 1 part in 10^5 and maintained by a 320-turn coil (1000 amp, 60 volts), and the magnet, energizing current and plateholder assembly are contained in a vacuum vessel $8\frac{1}{2}$ ft in diameter and 9 ft high.

The broad-range spectrograph for use with the 6 MeV generator is a single-channel type, but the angle of observation can be varied. The multichannel spectrograph is being built by an Aldermaston team and is costing about £25000.



The 20 MeV magnetic particle spectrometer

Harwell studies

There is news also of particle investigations at Harwell. A 12 MeV tandem generator, twin of the Aldermaston machine, is one of four new A.E.R.E. projects there. A 7 GeV proton synchrotron (Nimron) being built by A.E.R.E. and the Industrial Group should be ready by 1962, and a 50 MeV proton linear accelerator constructed by A.E.R.E. and industry recently came into operation. The latter machine is expected to have a proton-beam intensity many times greater than in other accelerators of the kind.

These two machines are for the Rutherford High Energy Laboratory of the National Institute for Research in Nuclear Science at Harwell and will be used by the Atomic Energy Authority, university physicists and a resident laboratory team. The fourth machine, a 25 MeV electron linear accelerator, has been built by industry for A.E.R.E.

Concentration of advanced courses

WHILE The Institution was engaged at its Summer Meeting at Harrogate from the 15th to 19th June, Mr. A. A. Part, Head of the Further Education Branch of the Ministry of Education, was taking part in the Annual Convention of the Yorkshire Council of Further Education at the Royal Baths in the same town.

On the 17th June he spoke of the difficult problems involved in the concentration of advanced courses at a limited number of centres. The history of part-time education had resulted in too many centres with very small numbers of students, and the Ministry of Education had for this reason prescribed minimum enrolment figures for existing courses.

Concentration was particularly important for advanced full-time and sandwich courses because they made especially heavy demands on staff and equipment. These courses were designed as an alternative to a university education but many technical colleges could not offer such an alternative.

Mr. Part thought that the country would only succeed in getting the quality it needed by building up a limited number of really strong centres. He was glad to see that of 2500 students working for the Dip.Tech. 1900 worked in the eight colleges of advanced technology.

Electronics and National Certificated

TECHNICAL colleges have been notified that courses of study leading to Ordinary National Certificates in electrical engineering should give more emphasis to the subject of electronics, if necessary at the expense of the topic of machines.

The Joint Committee for the Award of National Certificates and Diplomas in electrical engineering have pointed out to the colleges that the older syllabuses reflect the former predominance of power engineering. It has been suggested that such syllabuses may be inappropriate today, particularly with regard to the detailed study of direct-current machines which often forms a large part of the courses and especially where such courses would normally be followed by studies for the Higher National Certificate with specialization in the electronics field.

The type of syllabus likely to be acceptable to the committee would be one in which about 80% of the total electrical content of the final year's study covered general electrical theory, machines and electronics. The remaining 20% could deal with either machines or electronics or a combination of both depending on the requirements of the Higher National Certificate which followed.

Annual General Meeting of The Institution, 1959

THE PRESIDENT, Mr. S. E. Goodall, M.SC.(ENG.), F.Q.M.C., took the chair at the 87th Annual General Meeting of The Institution at 5.30 p.m. on the 14th May 1959 at The Institution of Civil Engineers. The following list of donors to the Library for the year ended the 31st December 1958 was taken as read:

P. Adorian
F. A. Benson
Prof. N. P. Bogoroditsky
A. C. Clarke
H. Cotton
Sir Thomas Eades
H. E. Farrow
E. H. Frost-Smith
W. J. Gibbs
Mrs. E. Hartree
E. Hughes
A. W. Keen
P. Kemp
W. B. Laing
W. F. Lovering
A. D. Morley
A. H. Morton
Prof. G. Oberdorfer
W. T. O'Dea
E. Openshaw Taylor
R. N. Renton
P. C. Sandretto
Prof. M. G. Say
J. Shepherd
L. T. Spence
H. G. M. Spratt
A. T. Starr
K. R. Sturley
A. G. Warren
J. L. Watts
P. A. West
A. T. Witts
E. Wolfendale
W. S. Wood

The President introduced the Annual Report by referring to the steady rate of increase in membership over the last few years. 'The total membership is now well over 44000, of whom 24000 are Corporate members. We seem to have stemmed the decline in Student membership, and the total membership of that class is now 4097, compared with 3798 a year ago.

'In the Introduction and in par. 11 there are references to the Special General Meeting on the 9th April 1959. We decided to include these references, despite the fact that the Report deals with the year ended the 31st March 1959, because the proposed revisions of the Bye-laws were the result of a thorough examination of the existing Bye-laws which was carried out by the Council during that period.

'During the year our activities in terms of scientific papers, publications, etc. have considerably increased, particularly in connection with conventions and symposia. We have had at these conventions a growing number of visitors from oversea, including more recently the Soviet Union and the United States, and we are glad of that.

'Those of you who have visited the Institution building recently will have noticed the conditions prevailing there. That, of course, is the reason for our meeting this evening in The Institution of Civil Engineers. Our own Lecture Theatre is in a chaotic state.

'At the Council meeting on the 23rd April 1959, the tender submitted by G. E. Wallis and Sons Ltd. for phases 2 and 3 of the reconstruction work, for £205120, was accepted. The cost of phase 1 is £150000. The sum, including consultants' and architects' fees, will be about £388000. We are making provision for a total probable cost of £400000, because it is well to have something in hand, particularly when adapting an old building. Stringent economy is being exercised; and only recently your Joint Building Sub-Committee (which is a sub-committee of the Finance Committee and the General Purposes Committee) went over things again and made absolutely certain that every item is fully justified.

'With regard to finance, we have had a favourable offer from our bankers which takes advantage of the fact that we have ample funds in hand at the beginning of each year, when the subscriptions come in, but reach the changeover point as the year goes on towards its close, so that in any given year it is only necessary for us to borrow extra money for building purposes on a short-term basis.

'The Institution is taking a leading part in an education project of Eusec, in conjunction with the O.E.E.C., aimed at a critical appraisal of the methods in force in Europe and America for training professional engineers. We believe that this work, which will take nearly two years to complete, will make a valuable contribution to the technological strength of the Western world.

'An important part is being played by our President-Elect and by our Immediate Past-President in the establishment of the new College of Engineering and Technology at New Delhi, the foundation stone of which was recently laid by H.R.H. the Duke of Edinburgh. Sir Willis Jackson is chairman of the technical committee which is advising on the equipment that this country, through an industrial fund, will provide for the college.

'Section G deals with Benevolent activities. There has been an increase in subscriptions and donations, but I should like to call attention particularly to the appeal in the Report for contributions to the Fund from members who at the moment make no contribution. I know that this does not apply to anyone in this room. But to say that it is not possible to spare a few more shillings a year is at least a very dubious contention; I do not believe that it cannot be done.'

The President proposed and **Sir Willis Jackson** seconded that the Annual Report be received and adopted.

Mr. L. W. Phillips commented on the transfer of two women to full membership. It was a matter for pride that The Institution was the first learned society to admit women to membership. Would the Council consider placing a photograph and biography of the first lady member, Mrs. Hertha Ayrton, in one of the downstairs rooms at Savoy Place?

Also, was it possible to circulate or in some way make public the discussions of the Medical Electronics Discussion Group?

It was pleasant to know that a fourth Education Discussion Circle had been formed, but 'Circle' was the wrong term: it was too exclusive and shut the right people out. Never before had the link between the engineering side and the teaching side in technical education been so strong. The Circles should not be confined to teachers talking about their own methods but should include engineers, because teachers by themselves were not sufficient to spread education.

Mr. Phillips felt that to improve the cohesion within The Institution every member ought to have some acquaintance with the Council. In future when voting papers went out there should be not only a short biographical notice of the person that they were asked to elect but a photograph of that individual. It was important, if they were to grow as a corporate body, that closer contact between the Council and the membership should exist, so that the

Council could feel that they had the full backing of the membership.

The Institution had grown by 3% in the year, and they were becoming a vast body which was getting more and more unmanageable. If they had a corporate body that was overweight they got all the tiresome effects of weariness and disease which should not be there. They now had in their Institution some who were there because they had to be and not because they wanted to be.

To get more of the real spirit of corporate fellowship they should try to have four groups in London instead of one main London group. They should have geographical groups in London holding separate, smaller meetings where members could get to know each other better.

His final word was on the place of The Institution in daily life. They were responsible for radio, television, that inhuman monster the computer and many other things which affected daily life, and they had to accept their moral responsibility. In his Presidential Address on the 3rd October 1957 Mr. Goldup had said:

'The world has been brought to the crossroads; one road leads to the destruction of world civilization as it now exists, the other to a better life for everyone—not only for those in backward countries but in highly developed countries too. It is we, the engineers and scientists, who are largely responsible for this position, and surely we are morally responsible for the way in which our work is used. Can we, or dare we, stand aloof from the social and political implications of what we have achieved? I am convinced that this question must sooner or later be given an answer. I am equally convinced that this great Institution of ours has a vital part to play in framing that answer.'

He put this inquiry to the Council: what steps had the Council taken during the last two years to answer that question, and what steps were they going to take in the future?

The President, replying, said that he would ask the General Purposes Committee to consider whether some appropriate record concerning Mrs. Ayrton could be established within the Institution building.

It was not possible to publish the proceedings of the Medical Electronics Discussion Group. People would not feel free to speak informally if they knew that their words would be recorded and published.

He asked Sir Willis Jackson to reply to Mr. Phillips's comments on the Education Discussion Circles.

Sir Willis Jackson emphasized that there was no intention within the Education Discussion Circles to exclude practising engineers and to limit the Circles to practising teachers, but there were many people who were both. Of the forty-odd thousand part-time teachers in the technical colleges of Britain, over 60% had their primary employment in industry and commerce. The Education Discussion Circles welcomed those men particularly. There were usually present quite a number of practising engineers, and the intermingling of those engineers with full-time teachers was very valuable.

The President remarked that Mr. Phillips's suggestion of including photographs in the voting papers might work both ways. 'Personally, I should deplore it very much!' He thoroughly endorsed, however, what Mr. Phillips had said about closer contact between the membership and the Council.

Mr. Phillips had suggested that The Institution was a vast, unmanageable body, subject to weariness and disease. 'I suggest that we are a large and active body in full vigour and extremely healthy.' There would always be, in an Institution which conferred the distinction of chartered membership, a proportion of members who were there merely for the title and nothing else. The Council deplored that as much as Mr. Phillips did.

The only members that they really welcomed were those who felt that they had something to give to the corporate life of The Institution. He was very proud to find, when he went as President to innumerable meetings during his year, that a very large proportion of the members quietly and unassumingly and in many different ways played a most important part and were doing what they could to further the interests, in the best sense, of the corporate body which they represented.

The suggestion of local geographical groups within the London area was a new idea, and they would give it consideration. It had to be remembered about London that travelling was convenient only to and from the centre and that journeys 'across country' were difficult.

His own conclusion about the relationship of The Institution with daily life was that there was not a great deal that they could do as a corporate body except encourage the individual members to play a much more active part in the extramural (in the electrical engineering sense) activities of citizenship and similar matters.

Mr. E. G. Goodhew referred to the National Certificate course and to the years assessed by The Institution. There had been a number of cases where students had had to start a fourth year without being aware of the results of their assessment for their third year. The registration had had to be made on the basis of an inspired guess by the principal of their college, late in September. The matter had been aggravated recently because some of the sandwich courses for the Dip.Tech. started early in September, and one of the requirements was a high pass in the third year of the National Certificate. Would the Council study the matter with a view to ensuring that all the results were available by about the middle of August?

The President answered that when he had been Chairman of the Examinations Committee he had instigated a careful inquiry into that point. The primary cause of delay was that the papers were not received in time from the colleges. They had done everything they could to reduce the time taken by their part of the procedure, but still the colleges were late with the papers.

Dr. P. A. Lindsay, though realizing that it was too late to make any major alteration to the scheme for the reconstruction of the Institution building, wanted it put on record that there were at least some members who felt unhappy about the proposed changes. He was thinking about the aesthetic effect of the alterations. In his opinion, the Lecture Theatre was in the worst possible taste imaginable, and they

had missed a golden opportunity to do something about it. He was afraid that in ten years' time they would be ashamed of their headquarters.

The President pointed out that feelings about architecture and room decoration were obviously matters of taste. They had consulted a competent professional architect and had obtained his plans. The Council had liked them and had submitted them to a Special General Meeting, and they had in due course been approved by the members, after having been published in considerable detail.

Mr. C. E. Strong felt that it would be a great pity if The Institution became an organization to which people had to belong. They could not govern the actions of outside people, but they ought to discourage any tendency on the part of those people to require membership of The Institution as a criterion for employment.

The motion that the Annual Report be received and adopted was then carried unanimously.

The President next asked the Honorary Treasurer to present the Accounts for the year ended the 31st December 1958.

Mr. E. Leete said: 'On the expenditure side of the Accounts, the first heading, management, needs a word of explanation. The first three items cover all the staff, including those employed in specialist capacities, such as the editorial, technical, education and examinations departments and the Library, and the purely administrative portion of the staff costs directly attributable to activities such as Institution meetings, conventions and local Centres.

'The Finance Committee are considering the advisability of submitting the Accounts in a new form, in which the actual staff costs incurred would appear under the appropriate headings to enable a truer picture to be given of the cost of each of the Institution's activities. This has been in the mind of the Secretary and his staff for some time, but it has not been attempted so far because of the extra cost of doing it accurately. The reconstruction of the building has enabled us to extend mechanization, and the additional work involved can, I hope, now be undertaken without increasing staff costs, despite the fact that the expenditure in 1958 must be reallocated on the new basis to enable comparative figures to be shown.

'The remaining items under this heading are small, but they must increase in proportion to our growing membership.

'The cost of operating the building shows little change on the previous year, but there will be, of course, an increase in 1959.

'I now come to the *Journal* and *Proceedings*. These cost more to produce in 1958 than 1957 by nearly £12000, but this has been more than offset by an increase of £18000 in the receipts from subscriptions, sales and advertisements. Of this additional sum, £7000 was paid by members and £11000 came from non-members, sales and advertisements. The net cost of printing and distributing the *Journal* and *Proceedings*, therefore, fell by approximately £6000.

'The next item calling for comment is conventions. Three were held in 1958, two of which, after including the cost of the publications, showed net losses and the third, on radio aids to aeronautical and marine navigation, a small surplus, which appears on the income side of the Accounts. Steps are being taken to make these conventions, including the cost of producing special parts of the *Proceedings*, self-supporting, because of their specialist nature. During the year the conventions have paid for themselves, but the sales of convention *Proceedings* have been slower than we had hoped, with the result that there is at present a net loss under these heads. Sales of these special parts will continue, and we may eventually recoup the whole of this expenditure.

'Local Centres and Oversea Branches expenses both showed an increase during the year, but this is the result of the increased membership and activities of The Institution.

'Following the total expenditure is the excess of income over expenditure for the year, namely £5057. I am confident that the members present are in complete agreement with me when I say that this margin, which is less than 2½% of the net income of nearly £217000 and only about 1·7% of the gross income of almost £300000 (obtained by adding to the total of £217000 the receipts for the *Journal* and *Proceedings* and tenants' rents), is far too small for an organization of our size and standing.

'Perhaps I should add a note of warning here about possible increased expenditure over which we have no control whatever, namely printing costs. You will know that at the present time there is a dispute in the printing industry. If only half the demands of the printing operatives are met, the cost to The Institution will be about £6000 per annum on our present output. You will realize, therefore, how slender and inadequate is the margin on which we are working, when it can be turned into a loss by a single stroke of somebody else's pen.

'Referring to the income side, it will be seen that members' subscriptions are up by £9000 on the previous year. This, I think, was partly due to many members getting up to date with their payment of subscriptions following the Chancellor's announcement last year that the Finance Act would include provision for subscriptions to professional societies to rank as an expense against income.

'Turning to the Balance Sheet, the pattern has not varied greatly, and the item of major interest at the moment is the Rebuilding Reserve Fund, which has been credited with the interest received on investments during the year and has been reduced by £9868, the progress payments on the rebuilding work begun last August. This sum is, of course, added to the capital or surplus account and to the first item on the other side of the Balance Sheet, the Institution buildings and lease.

'During the year The Institution received a legacy from the estate of the late Lt.-Col. J. P. O'Gorman amounting to £2000, which has been used to endow a scholarship fund.

'On the assets side, the market value of the Rebuilding Fund securities at the end of December 1958 stood at a little over £192000, against a cost of £224000. The market value of those securities increased by nearly £12000 during 1958. Their value today is almost £194000. These investments will, of course, have to be realized over the next year or so to pay for the reconstruction work.

'The trust-fund accounts which follow the Balance Sheet include the Hunter Memorial Lecture Fund for the first time.

This is being accumulated from yearly subscriptions of £350 gross under a deed of covenant, and it constitutes a memorial to the late P. V. Hunter, a former President and Honorary Member of The Institution.'

The President proposed and **Mr. G. S. C. Lucas** seconded that the Accounts be received and adopted.

Dr. P. A. Lindsay was concerned about a recent large increase in the price of convention supplements to the *Proceedings* and wondered whether something could be done. He also wondered whether the tremendous increase in the number of people interviewed on transfer from the class of Graduates to that of Associate Members was necessary. That procedure used to be more an exception than a rule, but it now seemed to be the rule.

The President replied that there were a variety of reasons for different convention supplements being charged for at different rates. Some conventions issued more papers than others, and printing costs had gone up. Also, the Council had decided that the membership as a whole ought not to carry any proportion of convention costs and that conventions should be self-supporting.

He thought that Dr. Lindsay's second point was out of order, but he would deal with it. The reason for the increase in the number of interviews was simple: they wanted to be as fair as they could to the candidates. Most of the people interviewed would be rejected if there were no interview.

Mr. P. N. Wyke pointed out that under the heading *Journal* and *Proceedings* they had spent in 1958 just over £21 000. Over the last nine years they had spent a fifth of a million pounds. He had examined the accounts of two smaller organizations who published proceedings. One did more than break even, and the other made quite a good profit. He had looked at two weekly technical journals and found that their income from sales was much the same as the *Journal* and *Proceedings* subscriptions and that the total volume of paper was similar. He assumed that they made a profit or they would not continue to be published. He asked the Council whether the *Journal* and *Proceedings* could not be made at least to pay for themselves.

The President answered that it was their primary purpose to be a learned society and disseminate information among their members, and even more widely, on the science of electrical engineering. It was a serious matter to restrict the publication of technical papers within The Institution.

Nevertheless, some attention had been paid to that possibility in the last two years because of the growing cost of the *Proceedings*. The *Journal* was in a sense a free issue and was an essential service for all members, providing as it did contact between the Council and the members and in addition giving a brief résumé of what was going on.

A number of close investigations had been made by the Papers Committee. One method of reducing costs was to encourage writers to get to the point more quickly. That the *Journal* and *Proceedings* were published at the lowest possible cost for what they attempted to do he did not think anyone who had been on the Papers Committee could possibly deny. They had examined all sorts of possibilities, such as cutting the quality of the paper and increasing still further the volume of advertisements and so on. Considering the volume of scientific material published, marked results had been achieved.

Mr. J. F. Fletcher referred to the decrease of about £30000, or some 15%, in the market value of the Rebuilding Fund investments. Were they as a corporate Institution permitted to invest such funds in other than trustee stock? Perhaps they might suggest 'blue chips', even in the electrical industry, or, if that were felt to be unwise, in some other big industry.

The Secretary, asked by the President to reply, said that until three years ago they had been obliged to invest in trustee securities, but then the Privy Council had showed a tendency to relax the rule in certain closely controlled conditions and allow a proportion of the investments to be made in 'blue chips'. Unfortunately, the type of 'blue chip' which had been accessible when they had been in the market had moved generally in the same direction, and they had not been able to buy enough of the permitted kind to prevent that general slide with the decline in the value of money.

Mr. Alan Cormack thought it most commendable that in 1958 the loss on the *Journal* and *Proceedings* was less than in 1957, and he thought that there had been an improvement in 1957 also. If they continued at that rate, in three years the *Journal* and *Proceedings* would be self-supporting.

The Treasurer had told them that in future the management figure might be broken down, but could they ask for some breakdown of the figure that night? What numbers of staff were employed and on what jobs?

The total number of staff was 175, from Mr. Brasher to the office girls, responded the President. Their salaries were, if anything, below the open-market rates. In view of the quality of the service which they got, they owed a great debt to the staff for the work that they did. Realizing the scope of the work, as detailed in the Report, they would agree that the staff was no more than adequate for the job in hand.

The motion for the adoption of the Accounts was then carried without dissent.

Mr. D. E. Lambert proposed that the best thanks of The Institution be accorded to the Honorary Secretaries of the local Centres and Sub-Centres, the Council's Representatives oversea, and the Honorary Secretaries of the Overseas Branches and Committees for their valuable services during the past year. **Mr. E. O. Taylor**, seconding, likened an Honorary Secretary to a swan. They all admired the way a swan glided over the surface of a lake, but they knew that he was paddling like hell underneath. The vote of thanks was carried with acclamation.

Mr. G. S. C. Lucas, Chairman of the Finance Committee, proposing a vote of thanks to the Honorary Treasurer, said that they had learned to lean rather heavily on Mr. Leete, but that was not the reason why Mr. Leete's wrist was in a sling that evening: he had injured his wrist at Easter in helping others in a motor-car accident. **Sir John Dean** seconded the vote, which was carried with acclamation.

Allen, Attfield and Co. were reappointed auditors for 1959–60.

That concluded the business of the Annual General Meeting, and members then heard from **Prof. E. C. Cherry** a lecture 'On the conceivable future of telecommunications.'

ANNUAL REPORT FOR 1958-59

Report of the Council presented at the Annual General Meeting on the 14th May 1959

Introduction

SECTION A Membership
SECTION B Institution Activities
SECTION C Technical Investigations
SECTION D Joint Activities with Other Bodies
SECTION E Education
SECTION F Institution Library and Publications
SECTION G Benevolent Activities
SECTION H Institution Staff

Appendices

APPENDIX A Membership Changes during the Year
APPENDIX B Growth of Membership over the last 15 years
APPENDIX C Meetings
APPENDIX D Index

Introduction

At the Eighty-Seventh Annual General Meeting of The Institution, the Council present their Report for the year ended 31st March 1959.

The steady rate of increase in the membership of The Institution over the last few years has been well maintained, although the number of proposals received during the year was rather less than the record figure achieved during 1957–58. The total membership now exceeds 44000, of whom nearly 24000 are Corporate Members.

The Council have completed an examination of the Bye-laws, and a number of desirable revisions were submitted for approval to a Special General Meeting of Corporate Members held on the 9th April 1959. With the exception of the changes proposed in Entrance Fees and Annual Subscriptions, the Council's recommendations were unanimously approved, subject to certain drafting improvements. A further Special General Meeting will be required to consider proposed increases in Entrance Fees and Subscriptions, and supporting financial and other details will accompany the notice calling this meeting.

There has been a marked increase during the year in the organization of conventions and symposia for the presentation and discussion of new electrical developments of special significance. Three meetings of this nature were held during the first three months of 1959, and each was very well attended by both members and non-members of The Institution. Arrangements for two more are in hand for April and May. The Council have decided that this type of meeting should be financially self-supporting, but in all cases a reduced registration fee is charged to members of The Institution.

The change in the title of the Radio and Telecommunication Section to Electronics and Communications Section in February 1959 recognized the growing importance of electronics as an integral part of electrical engineering. Furthermore, the substitution of the word 'communications' for 'telecommunication' is intended to define more accurately the scope of the Section within the context of electrical engineering as a whole.

The attendance of the President (Mr. T. E. Goldup) and the Secretary at the Conference of Commonwealth Engineering Institutions in Australia in March 1958, and at the Eusec Conference held in New York in April/May 1958, were the highlights of a world tour in the course of which they were able to form or renew contacts with members of many of the Oversea Branches of The Institution. An extremely warm and spontaneous welcome was extended to them everywhere.

Through The Institution's Oversea Branches, Committees and Joint Groups, members resident abroad are able to participate in some measure in activities similar to those available to members at home. Welcome additional opportunities for direct contact between The Institution and its oversea members have occurred where senior members travelling abroad for business or other reasons have addressed local meetings in the places they have visited.

The Institution has played an important part in supporting the new College of Engineering and Technology at New Delhi, for which plans have been drawn up by the Government of India in consultation with the British Government and representatives of the British engineering industry.

Finally, the Council recognize the debt which they owe to the many Honorary Officers of The Institution at home and oversea for the services which they have so willingly and ably performed. They wish to thank not only these Officers but also the large number of other members who have so ungrudgingly given of their time to furthering the objects of The Institution.

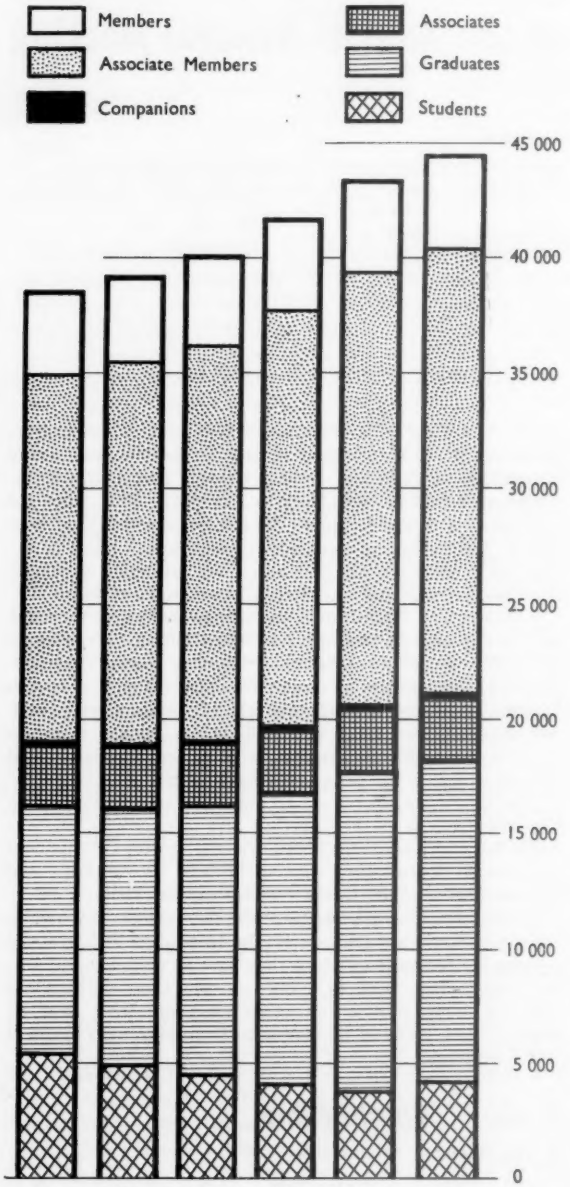
SECTION A Membership

1 The Register

The net increase of 1328 in the number of members of all classes, although lower than the record figure reached in 1957, was the third highest net annual increase during the last ten years. During the year, the Membership Committee considered proposals submitted by 5245 candidates, and the number of new members elected was 2350. It is gratifying to note that, although 908 Graduates were transferred to the class of Associate Members, the number of Graduates

increased from 13786 to 14015. There was also a notable increase in the number of Students elected, the total membership of that class being 4097, compared with 3798 in 1958.

On the 1st April 1959 there were 37734 Corporate Members and Graduates on the Register, representing 85% of the total



1 *Growth in membership*

membership of 44556. The total number of Corporate Members now approaches 24000.

Nearly 500 candidates attended for interview by representatives of the Council and thus were enabled to explain in person the degree of responsibility which they were undertaking.

The Council are pleased to report that they were able to approve the transfer from the class of Associate Members to the class of Members of Miss Dorothy Smith and Miss Kathleen Gough, B.SC. They were the first women to be admitted to full Membership since Mrs. W. E. (Hertha) Ayrton was elected on Lady Day in 1899. Three women were admitted to Associate Membership during the year, bringing the number of women in that class to 32 and the total for all classes of membership to 75.

2 Honorary Members

The Council take great pleasure in recording that they have elected Mr. C. W. Speirs, J.P., F.INST.P., F.C.G.I., MEMBER, to Honorary Membership of The Institution in recognition of his contributions to the advancement of electrical science and engineering, of his notable services in these fields and of his outstanding support of the work of The Institution, particularly of the Benevolent Fund.

3 Faraday Medal

The thirty-seventh award of the Faraday Medal has been made to Signor Luigi Emanueli, MEMBER, for his outstanding contribution of inventions and new applications in the field of electrical cables and particularly for the invention of the oil-filled cable.

The Council learnt with deep regret of the death of Signor Emanueli on the 17th February 1959, before the Medal could be presented to him. Arrangements have, however, been made for the presentation of the Medal to a representative of Signor Emanueli's family.

4 Principal Honours and Distinctions Conferred on Members

Knight Grand Cross of the Order of the British Empire
Citrine, The Rt. Hon. Lord, P.C., K.B.E., LL.D. (*Companion*)

Knight Commander of the Order of the British Empire
Axon, A. E., M.E. (*Associate Member*)
Peard, Rear-Admiral K. H. T., C.B.E. (*Member*)

Knight Bachelor
Jackson, Willis, D.SC., D.PHIL., DR.SC.TECH., F.R.S. (*Member*)
Pickles, J. S., B.SC.TECH. (*Member*)

Companion of the Order of the Bath
Chapman, Air Vice-Marshal H. H., C.B.E. (*Associate Member*)
McMillan, Col. D., O.B.E., B.SC. (*Member*)
Ray, F. I., C.B.E., B.SC.(ENG.) (*Member*)

Companion of the Order of Saint Michael and Saint George
Daw, Col. S. E. H., C.B.E. (*Associate*)
Follett, S. F., B.SC.(ENG.) (*Member*)

Commander of the Order of the British Empire
Ashdowne, Maj. H. A., B.SC.(ENG.), F.R.S.A. (*Member*)
Bellamy, D., O.B.E. (*Companion*)
Bevan, P. A. T., B.SC. (*Member*)
Butement, W. A. S., O.B.E., B.SC.(ENG.) (*Member*)
Clotworthy, S. E., B.SC.(ENG.) (*Member*)
Cowan, J. (*Member*)
Fletcher, P. T., B.SC.(ENG.) (*Member*)
King, J. L., O.B.E. (*Member*)
Ratcliffe, J. A., O.B.E., M.A., F.R.S. (*Member*)
Thompson, J. C., B.SC.(ENG.) (*Associate Member*)
Triggs, W. Warren, M.SC., B.E. (*Associate Member*)
Willoughby, G. P., O.B.E., M.SC.TECH. (*Member*)

Officer of the Order of the British Empire

Essen, L., D.SC., PH.D. (*Associate Member*)
Mann, R. W. (*Member*)
Tunstall, H. A. (*Companion*)
Watson, D. S., B.SC.(ENG.) (*Associate Member*)
Wheeler, E. F. (*Member*)
Woodbridge, A. W., M.SC.(ENG.) (*Member*)

Member of the Order of the British Empire

Brooke, H. A., B.SC.(ENG.) (*Member*)
Hogg, I. H., B.SC. (*Associate Member*)
Jarvis, W. H., F.R.S.A. (*Associate Member*)
Petrie, R. D. (*Associate Member*)
Psintros, C. J. (*Associate Member*)
Sills, G. F. (*Member*)
Stonehouse, M. D. W. (*Member*)
Walker, D. C., B.SC.(ENG.) (*Associate Member*)

Emergency Reserve Decoration

Lang, W. N., B.SC.(ENG.) (*Associate Member*)

Volunteer Reserve Decoration

Stewart, Cmdr. A. C., R.N.R. (*Associate Member*)

CHAPLAIN TO THE COUNCIL

Knight Commander of the Royal Victorian Order

Cresswell, The Rev. C. L., C.V.O., M.A.

5 Deaths

The Council record with regret the deaths of the following members of The Institution:

Members

Adams, Prof. C. A.
Allan, R.
Amberton, R.
Andrews, A. E. D.
Asdell, J. H., M.SC.
Atkinson, J.
Barker, E. A., M.C.
Barney, Sqdn.-Ldr. L. W.
Bear, M. M.
Blades, H.
Boyce, J.
Bramwell, F. H., B.SC.
Brookes, A., M.ENG.
Broughton, H. H.
Clayton, A. E., D.SC.
Cooper, J. S. St. G., M.A., B.SC.
Cosgrove, C. W., B.SC.(ENG.)
Crosbie, C. W.
Davies, A. W.
Dinham-Peren, A. E. H.
Eaton, R. N.
Eckersley, T. L., B.A., B.SC., PH.D., F.R.S.
Eckhard, K. N.
Emanueli, L.
Erlebach, W. A., B.SC.(ENG.)
Ewing, S. E. T.
Feltham, J. B.
Field, J. F., B.SC.
Fraser, H. G., M.C., T.D.
Fraser, W.
Garner, R. H., M.SC.TECH.
Gatehouse, E. A.
Gee, W. C.
Gilbert, T. C.
Girling, H. P.
Grant, J. W.
Green, H. H. R.
Green, J. D.
Gregory, R. W.
Grover, Lt.-Col. C. A., T.D.
Gueilikman, M.
Hartree, D. R., PH.D., M.A., M.SC.
Haslam, S. B., O.B.E.
Hedley, J., I.S.O.
Herbert, A. S.
Heurtley, E. S.
Hieatt, P. G.
Higham, J. B. J.
Howgrave-Graham, R. P.
Hughes, H. G., M.SC.
Jagger, H. H.
Johnson, E. M., M.SC.TECH.
Kirkwood, I. W. A.
Konstantinowsky, K., PH.D.
Lamb, Maj. L., T.D.
Lundberg, P. A.
McFarlane, W., O.B.E., B.SC.
Macgregor-Morris, Prof. J. T.
McKinney, J. A.
Marshall, A. G.
Mathieu, C. N.
Mavor, J. B.
Mersh, C. M. B., M.B.E.
Morris, E. S.
Morris, J. M., O.B.E.
Mulleneux, H. J., O.B.E., J.P.
Oswald, H.
Paterson, H.
Penney, A. E.
Picken, W. J., O.B.E.
Pike, M. A.
Powell, Prof. P. H.
Ram, W.
Reynolds, E. A., M.A.
Scott, G. S.
Shearing, G., O.B.E., B.SC.
Sherratt, T.
Sichel, G. M. S., B.SC.
Sillar, H. M.
Sloan, A. D.
Smith, A. E., B.SC.(ENG.)
Smith, S. B.
Somayajulu, B. R.
Soutar, G. R. C., B.SC.
Steele, E. W.
Steele, W. H.
Sundaram, G.
Swangren, E. G. F.
Thorpe, W. B.
Turnbull, H.
Waters, J. H.
Watts, Lt.-Col. H. W.

Associate Members

Agar, W. H.
Allam, E. B.
Allen, V. M.
Arkinstall, L. W.
Arnold-Jones, V.
Ashworth, F., B.SC., PH.D.
Bayles, E. A.
Beattie, W.
Bell, A. R.
Blacklock, C. W.
Boud, F. H.
Boyd, J. S.
Bradbury, J. A.
Brazier, Brig. C. C. H., O.B.E., T.D.
Briggs, W. T.
Brooker, W.
Brown, C. W.
Browne, P. A.
Buer, J. M.
Bullman, H. C.
Burchell, J. R. L.
Callow, E. W.
Carter, F. T.
Cattle, E. P. S.
Chubb, W. L.
Clague, A. R., M.ENG.
Clark, E. F., B.A., B.SC.(ENG.)
Clayton, H.
Clerk, A., B.SC.
Close, F. W.
Comerton, J. E., B.E.
Coulthard, W. B., B.SC.(ENG.)
Cox, A. W.
Cox, L. C.
Craig, T. I.
Darbyshire, J. A., M.SC., PH.D.
Dore, C. U.
Duff, D.
Dunn, C. T., B.SC.(ENG.)
Dupree, F. H.
Durrant, A. G.
Edwards, W. V.
Ellington, A. C.
Formby, W. L.
Fowler, W. E.
Francis, F. W.
Franks, H. W.
French, C.
Gardner, Col. J., B.A.
Gent, A.
Golding, T., O.B.E.
Goodwin, F. H. G.
Graham, R. B.
Green, Q. F. (Mrs.)
Gregory, A. W.
Grieve, K. G., B.SC.
Hall, E. F.
Hammond, G. W.
Harbottle, G. R.
Harpur, R. C.
Harrison, H. M., B.SC.TECH.
Hayward, G. B., M.B.E., B.A.
Helman, S. L.
Heynssens, J.
Hinley, H. C., B.SC.
Hopton, J. H.
Howard-Vyse, Col. C. E., O.B.E.
Hudswell, P. S.
Humphress, E. G., B.SC.(ENG.)
Humphreys, Maj. H. V., R.E.
Jack, R. G.
Jackson, T. F.
Jenkin, Maj. A.
Johnstone, A. S.
Jones, L. L., B.SC.
Kean, A. J. A.
Kerr, M. J. D., M.A.
Knight, F. J.
Lambert, A. B.
Leedal, R.
Lorkin, W. L.
MacArthur, J. A., B.SC.
McBretney, W.
MacDonald, S. J., B.SC.
McDowell, J. H.
Macilwraith, G. M.
Macklin, Maj. R. W., M.C.
Maguire, B. J.
Mould, J., Q.C.
Mousley, Lt.-Col. J. H., D.S.O., T.D., R.E.(RET.)
Murray, W. R.
Norton, H. J.
Olivant, W. M.
Owen, W.
Pearson, R. L.
Perkin, A. H.
Pettifor, P. G.
Phipps, W. A.
Pope, J. W., B.SC.(ENG.)
Proctor, B.
Ramsbottom, J. S.
Rangachari, T. S., M.A., M.SC.
Ray, J. W.
Reid, C.
Rhodes, W. J.
Roberts, A. H.
Roberts, Maj. W., M.C., R.A.
Robinson, R. T.
Rowan, N. C.
Rowse, E. J.
Russell, F. G.
Sard, P. J.
Shannon, J., B.SC.
Shaw, W.
Shill, P. R.
Slingerland, J. F.
Smith, H. H.
Smith, J. W.
Sutton, C. J.
Sutton, M. G.
Sweetinburgh, A. W.
Sykes, W. H.
Tarlton, H.
Thomas, D. F., B.SC.
Thompson, C. W.
Trigg, A., B.SC.
Tudor, W. C., M.SC.
Walton, A. L. G., B.SC.(ENG.)
Ward, A. G., B.SC.
Wardle, P.
West, H.
Whalley, D. E.
Whewell, H.
Whitney, H. E.
Wilson, J. C.
Wood, Capt. D. S.
Woods, E. F.
Woollard, F.
Wright, J. H., B.SC.(ENG.)
Young, J.
Young, J. H. M.

Companions

Hughman, R. W.
Ince, J. O.
Seshasayee, V.

Associates

Aiken, L. J. C.
Bedford, C. F.
Bowling, W. F.
Buick, J. P.
Burnett, E. D. F.
Burrows, J. J.
Collins, H.
Crow, A.
Davis, Maj. H. E.
Dickinson, R. H.
Downie, C. K.
Drewry, J. P. A.
Graham, G.
Graham, R. L.
Hanlon, E. M. G.
Hayes, P.
Heath, P. S.
Jacob, J.
Mead, R. H.
Millar, W. W.
Millatt, H. W.
Rivett, Maj. C., R.E.(RET.)
Robertson, L. R.
Ross, E.
Sedgwick, A. J.
Silver, H. G. E.
Smith, W. H.
Wheeler, W. S.
Willan, U.
Williams, D. T.

Graduates

Babicz, B. P.
Barretto, D., B.SC.(ENG.)
Collier, A.
Dexter, S., B.SC.
Freeman, D. L., B.SC.(ENG.)
Kaighen, J.
Lea, C. B., B.SC.(ENG.)
Lock, F. C.
Masey, E. W. H.
Mathur, R., B.SC.(ENG.)
Miller, R. W., B.SC.(ENG.)
Oddie, M. B.
Pryce-Jones, R.
Raymond, M.

Student

Skitt, R. F.

6 Members who have Retired, or who are of Long Standing

During the year, 166 members took advantage of a rule under which Members, Associate Members and Associates who have retired from the profession may apply to retain their membership without payment of further subscriptions, provided that they have reached the age of 60 and have had 25 years' continuous membership. A comparable rule applies to Companions, who must have reached the age of 70, and two Companions were relieved of the payment of their subscriptions under the rule.

Sixty-nine members qualified for a total remission of subscription under a rule covering members of any class who have completed 50 years' membership.

7 The Designation 'Chartered Electrical Engineer'

The Council commend the fullest use of the title 'Chartered Electrical Engineer', which now appears on all Diplomas of Corporate Membership.

8 Unauthorized Use of Membership Initials

The Council take firm action in all cases which come to their notice, and in 1958 satisfactory undertakings and apologies were received as a result from 21 offenders for making unauthorized use of designations of Institution membership.

The Council will be glad if members will bring the facts of any doubtful cases to the attention of the Secretary.

9 Income Tax—Members' Subscriptions

Members will have noted with satisfaction the Chancellor of the Exchequer's decision to treat subscriptions to professional societies as a charge against salaries and to grant the appropriate relief. This became law under Section 16 of the Finance Act, 1958, and The Institution was able to advise members, on pages 629 and 646 of the November and December issues of the *Journal*, that The Institution had been registered as an approved body whose members could claim relief from income tax on their membership subscriptions.

10 Revised Rates of Membership Subscriptions and Entrance Fees

The continued growth in both the size and activities of The Institution has had its inevitable repercussions on finances, and after two years of exceedingly small revenue surpluses the Council found themselves obliged, once again, to ask the membership to pay higher subscriptions.

The Council regret that this action became necessary but are convinced that the only alternative, to reduce activity and publications, would seriously hinder the work which it is our duty to perform.

11 Bye-law Amendments

A Special General Meeting of Corporate Members of The Institution was held on Thursday, 9th April 1959, when changes in the Bye-laws proposed by the Council were considered. An amendment that the changes proposed to Bye-law 26—Entrance Fees, and Bye-law 27—Annual Subscriptions, be deleted was adopted by a small majority.

In the discussion, many speakers requested fuller details of the financial background and sufficient opportunity for these to be considered before a final decision on the proposed increases was reached.

In his replies, the President undertook that when proposals for increases in the Entrance Fees and Annual Subscriptions were submitted to a further Special General Meeting, supporting financial and other details, reference to which had been made in the discussion, would be circulated with the notice convening the meeting.

Amendments were also adopted making textual changes representing drafting improvements in Bye-law 12 and deleting the words 'and that the work upon which he is engaged is conducive to this end' where they were proposed to be introduced in sub-paragraph (b) of Bye-law 15.

Subject to these amendments, the changes proposed were adopted unanimously and will go forward for allowance to the Lords of Her Majesty's Privy Council, as the Royal Charter requires.

The Meeting was attended by less than 100 Corporate Members, and the President stated that 178 valid proxies had been received.

SECTION B Institution Activities

12 Meetings

During the twelve months ended 31st March 1959, 1419 meetings of the members, the Council and the various Committees were held in London and at the Local Centres, an increase of 12 compared with the figure for 1957–58. A detailed statement is given in Appendix C, and Fig. 2 shows the number of meetings held during the past six years.

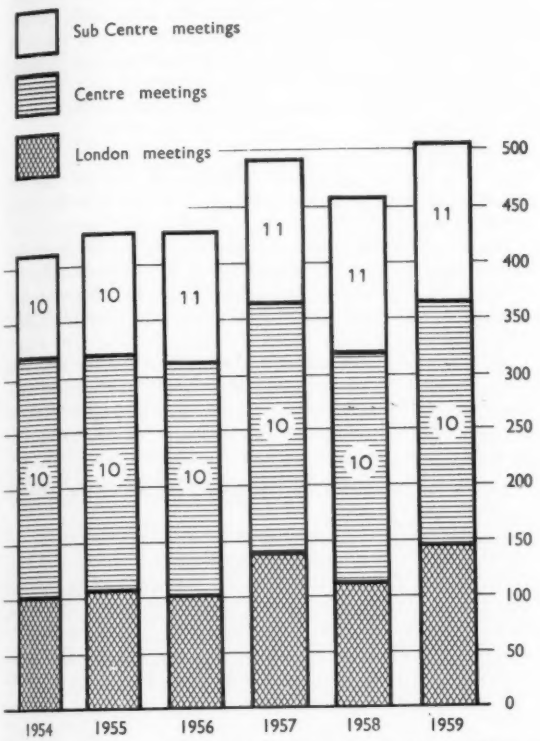
Ten Ordinary Meetings were held in London, with an average attendance of 252. The papers read and the ensuing discussions are recorded in the pages of the *Proceedings*. In addition the Annual General Meeting and one joint meeting with The Institutions of Civil and of Mechanical Engineers were held. Five meetings were held in conjunction with the British Nuclear Energy Conference.

The Fifth Graham Clark lecture arranged by The Institution of Mechanical Engineers was delivered in March 1959 by Sir Arnold Plant, B.SC., B.COM. It was entitled 'Engineering in an expanding economy'.

A public meeting was held at the Royal Festival Hall,

London, for the delivery of the 1958–59 Faraday Lecture by Dr. H. A. Thomas, MEMBER (see par. 23).

The First Hunter Memorial Lecture on 'P. V. Hunter—electrical engineering in our time' was given by Mr. C. O. Boyse, B.SC.(ENG.), MEMBER, in London and in Liverpool, Newcastle upon Tyne and Middlesbrough.



2 *Total number of Meetings held in London and in the Centres and Sub-Centres*

13 Specialized Sections

The work of the specialized Sections continues to increase, and there has been a corresponding increase in their membership, as will be seen from Fig. 3. The following statement shows the membership of the Sections, the number of meetings that have been held and the average attendances.

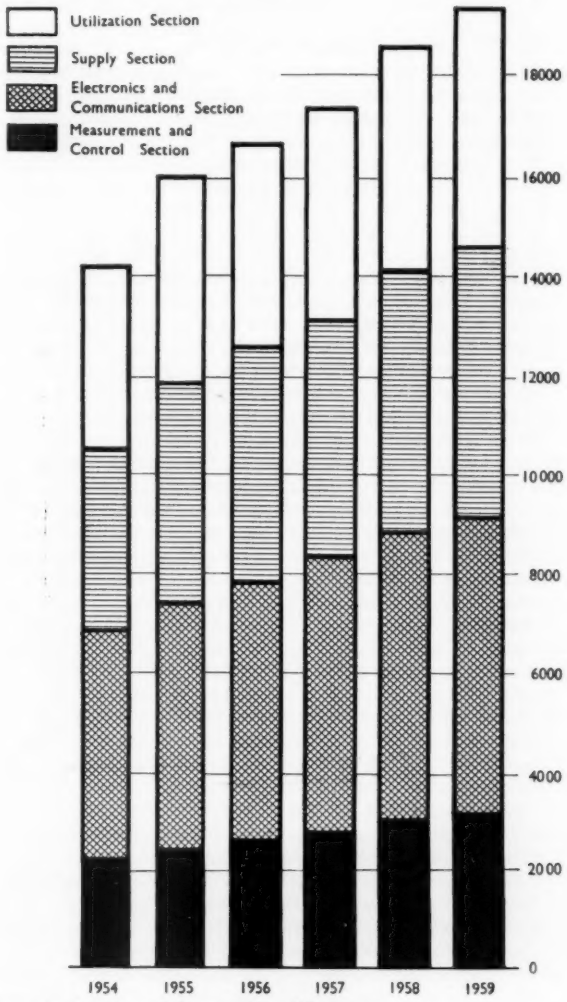
	Membership at 31st March 1959	Number of meetings	Average attendance (figures for last year in brackets)
Electronics and Communications	5974	50	177 (237)
Measurement and Control	3182	20	148 (92)
Supply	5439	9	141 (115)
Utilization	4813	8	126 (115)

Measurement and Control Section

The Committee have received 51 papers during the year; 6 were accepted for reading at meetings and 19, of a specialist character, for publication only. A number of papers are still under consideration.

The Annual Lecture was delivered on the 6th May 1958 by Dr. A. T. Starr, M.A., B.SC., MEMBER, his subject being 'Some case-histories of business computers in the U.S.A.'.

The Summer Visit took place on the 7th June 1958, when 100 members and their ladies visited the B.B.C. television studios in London and the Electricity Council's Training Establishment at Horsley Towers.



3 *Membership of the specialized Sections*

In the morning the party visited the B.B.C. Television Centre, Wood Lane, and afterwards toured the B.B.C. studios at Lime Grove and Riverside. The party was entertained to lunch at the Television Centre. In the afternoon a tour was made of the National Trust Regency Villa at Polesden Lacey, where tea was taken. They then visited the Electricity Council's Training Establishment at Horsley Towers, where they were entertained to dinner by the London Electricity Board.

The Section Dinner was held at the Café Royal, London, on the 11th November 1958. The principal guest was Brig. Sir Lionel H. Harris, K.B.E., T.D., and the company present numbered 275. The Section again joined with the Electronics

and Communications Section in a Dinner-Dance (see below).

On the 16th–17th February 1959 a series of Specialist Discussion Meetings on New digital-computer techniques was held at Savoy Place. These informal Discussion Meetings, at which contributions were presented in six sessions, aroused great interest, and 487 registrations were received.

Electronics and Communications Section

On the 5th February 1959 the Council approved a recommendation that the title of the Section be changed from Radio and Telecommunication Section to Electronics and Communications Section, in order that the field of activity of the Section might be more adequately described.

At the end of the 1957–58 Session, two Section Meetings devoted to the presentation of formal papers were held and, in addition, two Informal Evenings. At the beginning of the current session, the Section Committee rearranged the programme so that, in general, the normal Section Meetings would consist of lectures of broad general interest and the more specialist papers would be read at additional Section Meetings. So far, in addition to the Chairman's Address, six lecture-type meetings have been held and eight which have been devoted to the reading of papers. The Section Committee consider that this new approach is effectively meeting the needs of members of the Section.

An International convention on Microwave valves was held during the period 19th–23rd May 1958 and was attended by more than 750 participants, of whom 150 had come from 15 oversea countries. On the 29th and 30th January 1959 a Convention was held on the subject of Long-distance transmission by waveguide, for which there were about 300 registrations, and on the 19th and 20th March 1959 400 participants engaged in a Convention on Stereophonic recording, reproduction and broadcasting. Arrangements for an International convention on Transistors and associated semiconductor devices and a related International Scientific Transistor Exhibition to be held at Earls Court in May 1959 are almost complete. 279 papers have been submitted to the Committee for consideration; of these, 174 related to the conventions.

On Saturday, 21st July 1958 a total of 150 members of the Section, and their guests, visited British Telecommunications Research Ltd. at Taplow for an exhibition depicting the work of the groups associated with B.T.R., and a trip on the River Thames. Throughout the day the party were the guests of British Telecommunications Research Ltd. A party numbering 70 visited Paris during the period 25th–28th September 1958. The programme included visits of technical and general interest and a Section Dinner. The concluding social event of the year was a Joint Dinner-Dance with the Measurement and Control Section, held at the Café Royal on the 10th February 1959, when about 230 members and their guests were present.

Supply Section

A total of 29 papers was considered during the year, and 19 of these were accepted, nine for reading and discussion. One Supply Section paper was read at an Ordinary Meeting.

At the invitation of the Scottish Centre Committee, the Section Visit was held in Edinburgh from the 18th to 21st September 1958 and was attended by a record total of 254 members and their ladies.

A visit to Leatherhead took place on the 31st May 1958, when members visited the Electrical Research Association's Laboratory while the ladies were shown round the Electrical Development Association Testing House. The attendance on this visit was 118.

The Annual Dinner-Dance was held on the 11th March 1959 at the Connaught Rooms, when a record total of 379 members, and their ladies, were present.

Arrangements are well advanced for a Section Visit to Dublin from the 10th to 13th September 1959 at the kind invitation of the Committee of the Irish Branch. In addition, a visit to the Associated Electrical Industries Laboratory at Aldermaston will take place on the 23rd May 1959.

Utilization Section

From a total of 26 papers submitted during the year, 14 were accepted and, of these, three were allocated for reading at meetings.

The Annual Lecture was delivered by Dr. P. T. Standring on the 8th May 1958, his subject being 'Artificial fibres'.

The Section Summer Visit, attended by 137 members and their ladies, was paid to Porthcawl from the 16th to 18th May 1958.

The Section Annual Dinner-Dance was held at the Café Royal on the 16th January 1959 and was attended by 205 members and their ladies.

14 Informal Meetings

The seven Informal Meetings held during the year covered a wide range of subjects.

The object of these meetings is to give opportunity for the free and informal discussion of a range of topics, wider in scope than is found in any other part of The Institution programme. Incidentally, they provide a means whereby the younger or more diffident members can gain experience in making their opinions known in public, thereby acquiring confidence to take part in discussions on papers read at Ordinary and Section Meetings.

The proceedings are entirely informal, and no report is permitted.

15 Medical Electronics Discussion Group

In September 1958 the Council, with the encouragement of members of the medical profession, instituted a Medical Electronics Discussion Group to provide a forum in which electrical engineers, specializing in electronics, could meet members of the medical profession to discuss problems in which they had a common interest. The Group hold regular monthly meetings having the nature of colloquia at which subjects coming within the field of medical electronics are discussed.

The affairs of the Group are guided by a Committee broadly representative of members of both professions who are prominent in this field.

The 'mailing list' of the group has increased to 375, and additions to it may still be made.

The Council noted with interest the outcome of the International conference on Medical electronics which, on the initiative of Dr. V. K. Zworykin, was held in Paris in June 1958 and felt that the Second international conference, which is to be held in June 1959 in Paris, was worthy of support. They therefore agreed that the Group Committee should receive notice of any papers coming from British sources, for submission by Dr. C. N. Smyth, M.A., B.SC.(ENG.), M.B., B.CH., MEMBER, a Vice-President of the Interim

Committee of the International conference and Chairman of its Papers Committee.

16 Local Centres and Sub-Centres

343 meetings of a general character were held during the year by the ten local Centres, the 11 Sub-Centres and the 11 specialized Groups compared with 347 during the previous year. 20875 members are attached to the ten Centres, the figures being as follows:

East Midland	1902	North-Western	3216
Mersey and North Wales	1458	Scottish	1973
North-Eastern	1599	South Midland	3715
Northern Ireland	353	Southern	2000
North Midland	1999	Western	2660

In addition to the general meetings a number of social functions have been held, at several of which the President, accompanied by the Secretary, was present. The Vice-Presidents have also visited many of the Centres and Sub-Centres and have deputized for the President at a number of social functions.

The interests of local members of the four specialized Sections have been met wherever possible by the 11 specialized Groups; several Groups were visited by their respective Section Chairmen.

During the year adjustments have been made to the North-Western/South Midland Centre and East Midland/South Midland Centre boundaries which have resulted in improved services for the members concerned.

The Annual Conference of Honorary Secretaries of Local Centres and Sub-Centres was held to coincide with the Annual Dinner of The Institution, at which the Honorary Secretaries were present by invitation of the President and Council. The conference gave these officers an opportunity to discuss many matters of common interest relating to their work for The Institution.

The following Honorary Secretaries of Centres and Sub-Centres have tendered their resignations during the year under review:

Mr. E. Bolton, B.SC.TECH., ASSOCIATE MEMBER, North Staffordshire Sub-Centre, after three years of service
Mr. E. S. Hall, MEMBER, Rugby Sub-Centre, after six years of service
Mr. T. M. McCammont, ASSOCIATE MEMBER, North Scotland Sub-Centre, after two years of service
Mr. J. G. Winnard, ASSOCIATE MEMBER, Tees-Side Sub-Centre, after five years of service

The Council welcome this opportunity of recording their sincere appreciation of the services these members have rendered to The Institution.

17 District Meetings

The District Meetings, including a number held particularly for Graduates and Students, which have been held in many places throughout the country where membership of The Institution is too small to justify the provision of meetings of a more formal type, have continued to be extremely successful. Many members who would have little opportunity of attending other meetings of The Institution have expressed their appreciation of this facility. The work performed by the conveners of District Meetings is greatly appreciated by the Council.

18 Graduate and Student Sections

The Committees of the 19 Graduate and Student Sections have continued their efforts to attract more members to their meetings, visits and social functions, and several are now achieving more satisfactory attendance figures. Two Sections, the North Midland and the Sheffield, held week-end conferences. These were highly successful, and the two Committees concerned are to be congratulated on their enterprising spirit.

The Students' Lectures this year are entitled 'Something for nothing?—Heat-pump achievements' and 'Developments in lighting' and are being given by Mr. G. O. McLean, M.ENG., ASSOCIATE MEMBER, and Dr. F. A. Benson, M.ENG., ASSOCIATE MEMBER, respectively.

The Annual Conference of Honorary Secretaries of Graduate and Student Sections was held in November 1958. The suggestions made by that conference are being considered, with other matters, by the Committee on Graduate and Student Section Activities.

19 Oversea Activities

The ten Oversea Branches and Committees have continued to arrange meetings, visits and social functions appropriate to local conditions. Visits from senior members are always welcome, and those who are going abroad and are prepared to address members or to present an Institution paper are invited to communicate with the Secretary of The Institution.

Many oversea members have called at Headquarters during the year, about 200 having signed the oversea register. Letters of introduction have been provided for a large number of members travelling abroad and to other members who have taken up oversea appointments during the year. Very favourable reports have been received of the help given to these members by the secretaries of the national engineering societies to whom the letters of introduction were addressed and with whom The Institution has reciprocal arrangements.

In the course of their journeys to and from the Commonwealth Engineering Conference in Australia and the Eusec Conference in New York, the President (Mr. T. E. Goldup) and the Secretary visited Oversea Branches, Oversea Committees and Joint Oversea Groups in Iraq, India, Malaya, Singapore, Australia and New Zealand and also met members in several different parts of Canada. This opportunity of seeing at first hand the work of the Oversea Branches and Committees and of meeting a large number of oversea members was much welcomed.

The six Joint Oversea Groups of the three Institutions have all been very active and have fulfilled a real need in providing facilities for meetings for members of the three Institutions in the parts of the world where they have been formed. Meetings on a joint basis are being held in Gibraltar, and proposals have also been put forward for the formation of Joint Groups in Ghana and British Guiana.

During the year the following Oversea Representatives have been appointed by the Council:

Canada
Ontario: Mr. F. S. Barton, C.B.E., M.A., B.SC., MEMBER
Quebec: Mr. F. L. Lawton, B.A.SC., MEMBER

Ceylon
Mr. D. M. Gill, ASSOCIATE MEMBER (in place of Mr. J. G. Park, who has returned to this country)

East Africa
Tanganyika: Deputy Oversea Representative, Mr. J. H. Griffiths, MEMBER
Uganda: Deputy Oversea Representative, Mr. J. M. Stock, O.B.E., M.ENG., MEMBER

To meet changed conditions the title of the Iraq and Persian Gulf Joint Group has been changed to 'Middle East Joint Group'.

India

Bombay: Deputy Oversea Representative, Mr. J. H. Smyth, B.SC., MEMBER

Delhi: Deputy Oversea Representative, Mr. Shiv Narayan, SC.D., M.SC., B.E., M.A., B.SC., MEMBER

Madras: Deputy Oversea Representative, Mr. J. Meek, B.SC.(ENG.), MEMBER

Near East

Mr. H. D. Furber, ASSOCIATE MEMBER (in place of Mr. A. G. Coates)

20 Institution Conversazione

Following the successful experiment of reviving the Conversazione in 1956, which was held at the Royal Festival Hall, a charge being made to members for tickets, a similar function was held at the Royal Festival Hall on the 25th June 1958, when more than 2000 members and guests attended. An account of the proceedings was published in the *Journal* for August 1958.

In view of the undoubted success of these two functions, the Council have now decided to hold this event in alternate years, and the next occasion will be at the Royal Festival Hall on the 23rd June 1960.

21 Annual Dinner

A total of 1457 members and guests were present at the Annual Dinner, which was held at Grosvenor House, London, on the 26th February 1959.

The Rt. Hon. The Viscount Kilmuir, G.C.V.O., the Lord Chancellor, was the principal guest and proposed the toast of 'The Institution', to which the President replied. The toast of 'Our Guests' was proposed by Mr. T. E. Goldup, C.B.E., IMMEDIATE PAST-PRESIDENT, and the response was made by Sir Norman Kipping, J.P., Director-General of the Federation of British Industries.

A full account of the function appears in the May 1959 issue of the *Journal*.

22 Summer Meeting

No Summer Meeting was held in 1958, but at the invitation of the Chairman and Committee of the North Midland Centre arrangements are being made to hold a Summer Meeting in the area of the Centre from the 15th to 19th June 1959.

For 1960, the Council, on behalf of The Institution, have accepted with pleasure an invitation from the Chairman and Committee of the Scottish Centre to hold a Summer Meeting in Scotland.

23 Faraday Lecture

This year's Faraday Lecture, 'Automation', was presented by Dr. H. A. Thomas, MEMBER, at public meetings held in Swansea, Bristol, Birmingham, Leicester, London, Southampton, Manchester, Liverpool, Belfast, Sheffield, Leeds, Newcastle and Edinburgh. In Birmingham, Bristol, Edinburgh, Leicester, Liverpool, Southampton and Swansea, additional lectures were given before audiences of senior schoolchildren in conjunction with the local education authority. The Lecture was outstandingly successful, and everywhere that it was given the number of applications for tickets exceeded by far the seats available.

The Council are very grateful to Dr. Thomas and to his Company, Unilever Ltd., for their support.

24 Exhibitions of Outstanding Scientific Interest

Exhibits dealing with the following developments of scientific interest have recently been shown in the Institution building:

Water-cooled radar chassis
Linear accelerators
Scale model of ACE computer at National Physical Laboratory
All-transistor digital voltmeter

and the following are in preparation:

Developments in lighting technique
Early toruses used in nuclear fusion experiments
Synchro units for the transmission of angular-position information.

25 Institution Building

Phase 1 of the Reconstruction Scheme, described at the last Annual General Meeting, involving alterations to the third floor, was duly commenced last autumn, together with long-needed improvements in the Library which were completed before the opening of the session. At that time it was thought that on completion of phase 1 a further phase could be undertaken without having recourse to borrowing, it being the intention that the third and final part of the work would be left until more favourable circumstances prevailed. In view, however, of the marked improvement in the general economic situation in the latter part of 1958 and subsequently, it was decided that it would be financially advantageous to complete the whole scheme as quickly as possible. In the meantime a new lease was negotiated with the Duchy of Lancaster, in accordance with the authority given at the Special General Meeting of members held in June 1957, thus ensuring security of tenure for a period of 99 years from March 1959.

The preparation of the estimates for phases 2 and 3 of the scheme, merged into one and planned to overlap with the rest of the work in phase 1 (due to be completed by the 30th September 1959), was duly undertaken, and on the advice of the architects negotiations for a tender then proceeded with the general contractors for phase 1, G. E. Wallis and Sons Ltd. The result of these negotiations and the proposed financial arrangements will be placed before the members at the Annual General Meeting when the present Report is considered.

As stated in the March 1959 issue of the *Journal* (p. 134), the merging of phases 2 and 3 gives the advantage that work on the enlargement of the Lecture Theatre and on the additional Meeting Room on the ground floor is being undertaken earlier than was previously planned. In order, however, to reduce interference with the normal sessional programmes, the Lecture Theatre enlargement is being divided into two parts, one for completion by the 30th September 1959 and the other to be carried out during the summer months of 1960.

[*Note*—An architect's drawing showing the final external appearance of the building and a drawing of the larger Lecture Theatre were reproduced on p. 354 of the June 1957 *Journal*. Also, a detailed revised lay-out of the ground floor was shown on p. 638 of the December 1957 *Journal*. (Lantern slides of these drawings etc. will be available for the Annual General Meeting.)]

The rearrangement of the Library was carried out between the 1st August and the 8th October 1958 in order that it should be completed by the opening meeting of the 1958–59 Session.

The main task involved moving eight bays, each comprising 96 feet of shelving, from the south wall and building them end on into the shelving under the gallery on the north wall. So that this could be done, temporary shelving to accommodate over 10000 books and periodicals was erected. While this work was going on, the ceiling and walls were painted, 120 feet of new shelving was put in position between the windows on the south wall, and new lighting fittings were installed and wired. The Reference Library suffered some interference at the peak of the work, but the Lending Library services were maintained throughout. After the contractors had finished, the books and volumes, filling over 3000 feet of shelving, were thoroughly cleaned and arranged in order and the shelves relabelled.

The new arrangement allows seating for 24 members with good natural lighting from the windows, while the illumination from the new lighting fittings is of a correspondingly good standard. The inquiry desk has been moved onto the platform where it forms a focal point. From it, adequate supervision of the Library can be maintained.

26 Rating Relief

The Council accepted an invitation to give evidence before the committee appointed by the Minister of Housing and Local Government to review the present treatment for rating of hereditaments in England and Wales occupied for purposes of a charitable nature or for other similar purposes (the Pritchard Committee) and joined with the Councils of The Institution of Civil Engineers and The Institution of Mechanical Engineers in submitting a joint memorandum.

The Council have also followed with interest the successive stages of the case put forward by The Institution of Mechanical Engineers for relief from the payment of rates under the provisions of the Scientific Societies Act, 1843. A decision in that Institution's favour given by the Lands Tribunal is about to be reviewed in the Court of Appeal.

27 Faraday House, Hampton Court Green

In May 1958 the Council agreed to a proposal that a plaque be placed on Michael Faraday's house in Hampton Court Green.

Twickenham Borough Council were asked to make the necessary arrangements, the cost being met out of The Institution's funds. An agreement was reached with the Borough Council and with the Commissioners of Crown Lands, the landlords, and the house now bears a suitable plaque commemorating Faraday's residence there.

28 Gift by the B.B.C.

The Council gratefully acknowledge a gift by the B.B.C. of two radio microphones for use in the Lecture Theatre.

SECTION C Technical Investigations

29 Codes of Practice

The Council for Codes of Practice (CP/–), which was reorganized in 1954 with the support of the professional institutions, operates within the framework of the British Standards Institution with the status of a Divisional Council. Electrical Codes are prepared under the supervision of its Codes of Practice Committee for Electrical Engineering (ELCP/–), the secretariat for which is provided jointly by The Institution and the British Standards Institution. The Institution continues to provide the secretariat for the majority of the Electrical Code Drafting Committees. Codes dealing with radio-interference abatement are referred to in par. 30.

The following Codes have been issued during the year:

CP 1008: Maintenance of electrical switchgear
CP 1009: Maintenance of insulating oils
CP 1010: Loading of transformers

Account is being taken of comments received following the circulation of the following draft Codes:

Earthing (comprehensive recommendations for generating and substations; overhead lines; low-, medium- and high-voltage systems)
Revision of CP 327.201: Broadcast reception, sound and television by radio
Revision of CP 1003: Flameproof and intrinsically-safe electrical equipment

The following draft Codes have been approved for circulation for general comment:

CP 321: Electrical installations, to take the place of the existing CP 321: Electrical installations—general, and CP 321.101: Choice, installation and maintenance of electric wiring systems
Maintenance of motor control gear

The drafting of the following Codes is proceeding:

Climate-proofing of electric equipment
Measurement and abatement of radio interference in aircraft

The partial or complete revision of the following Codes is under consideration:

CP 321.102: Installation and maintenance of electrical machines, transformers, rectifiers, capacitors and associated equipment (revision nearing completion)
CP 324.102: Provision of electric lighting in schools
CP 326.101: Protection of structures against lightning
CP 327.300: Sound distribution systems
CP 327.402: Staff location systems
CP 327.404/402.501: Electrical fire alarms
CP 1002: Abatement of radio interference from electro-medical and industrial radio-frequency equipment
CP 1004: Street lighting

The preparation of the following new Code has been authorized:

Dust-tight enclosures for electrical equipment

Contact is maintained with Oversea Representatives of the Council and with Secretaries of Oversea Branches and Committees, to whom new Codes and drafts are regularly circulated.

30 Committee on Radio Interference

The need for interference abatement in the high-frequency broadcasting and television bands (Bands II and III) has been further explored; a number of the bodies represented on the Committee on Radio Interference have collaborated in this work.

The activities of a number of subcommittees, convened jointly by The Institution and the British Standards Institution, who are examining various technical issues—one of which deals with relations with the Special International Commitee on Radio Interference (C.I.S.P.R.)—have continued to receive the support of the Committee. The Committees dealing with Codes of Practice (see par. 29) maintain liaison with the Committee on matters of policy and with Technical Committee ELE/32 of the British Standards Institution on matters of standardization.

The advice of the Committee is available to the Postmaster General on any matters within their purview which may arise.

31 Committee on Regulations for the Electrical Equipment of Aircraft

This Committee and the Committee on Radio Equipment for Civil Aircraft have given further consideration to proposals from the Air Registration Board for the amendment of the non-mandatory part of the British Civil Airworthiness Requirements which deals with voltage and frequency tolerances in aircraft electrical supplies.

32 Committee on Radio Equipment for Civil Aircraft

The Committee have formulated, at the request of the Air Registration Board, maximum tolerable levels of radio interference from complete electrical installations in aircraft and have recommended that a British Standard Code of Practice be drawn up to give guidance on methods of meeting these levels. The preparation of this Code has reached an advanced stage (see par. 29).

The Committee have further considered, in consultation with the Committee on Regulations for the Electrical Equipment of Aircraft, the question of voltage and frequency tolerances in aircraft electrical supplies.

33 Model Forms of General Conditions of Contract

The preparation of the following new Model Form, for inclusion in the series promulgated on the authority of the Council of The Institution and the Council of The Institution of Mechanical Engineers, is nearing completion:

B.2.—Export Contracts with delivery f.o.b., c.i.f. or f.o.r., including Supervision of Erection

Further Model Forms which are proposed to be added to the range for export contracts are intended to deal with delivery f.o.b. or c.i.f. (short version of the published Form B.1) and with delivery f.o.b. or c.i.f. with erection on site.

Consideration is being given to the need for revision of Model Form 'A'—Home Contracts, with Erection, which was last revised in 1948.

34 Wireless Telegraphy Act, 1949

The work of the Postmaster-General's Advisory Committee set up to study interference caused by industrial, scientific and medical equipment has continued, and a report has been submitted to the Postmaster-General. For this Committee, as in the case of the others which preceded it, The Institution jointly with the Post Office provide the secretariat.

35 Economic Commission for Europe: Working Party on International Forms of Contract for Heavy Engineering Equipment

On the nomination of the Council and of the Council of The Institution of Mechanical Engineers, H.M. Government appointed Mr. J. F. St.G. Shaw, B.SC.(ENG.), MEMBER, to serve as one of the U.K. delegates to the eighth and subsequent sessions of this Working Party. Mr. K. F. A. Johnston, B.A., the second nominee of the two Institutions, and Mr. H. B. Morton continue to serve.

The above-named are members of the Joint Committee with The Institution of Mechanical Engineers and The Institution's own Committee on Model Forms of General Conditions of Contract.

SECTION D Joint Activities with Other Bodies

36 Co-operation between Engineering Institutions

Maintaining their close collaboration, the Presidents of The Institution of Civil Engineers, The Institution of Mechanical Engineers and The Institution of Electrical Engineers have met at intervals to interchange views on matters of common interest and concern.

The work of the Joint Advisory Committee on Education (JACE) is described in par. 56 and of the British Nuclear Energy Conference in par. 38.

Following action initiated jointly by the three institutions, the British Conference on Automation and Computation, described in par. 39, has continued and extended its work.

37 Parliamentary and Scientific Committee

This Committee provides a meeting-place for Members of Parliament on the one hand and representatives of pure and applied sciences on the other.

The Institution supports the Committee as an Associated Member, and Sir Harold Bishop, C.B.E., B.SC.(ENG.), PAST-PRESIDENT, continues as the Council's representative.

38 The British Nuclear Energy Conference

The Conference continues very successfully to co-ordinate the work of the collaborating societies in the technology of nuclear energy.

The Conference has been extended by the adherence of the Joint Panel on Nuclear Marine Propulsion, which incorporates four societies:

The Institute of Marine Engineers
The Institution of Naval Architects
The Institution of Engineers and Shipbuilders in Scotland
The North-East Coast Institution of Engineers and Shipbuilders

Sir Josiah Eccles, C.B.E., D.SC., PAST-PRESIDENT, Sir Willis Jackson, D.SC., D.PHIL., DR.SC.TECH., F.R.S., VICE-PRESIDENT, and the Secretary serve as The Institution's representatives on the Board of the Conference.

39 British Conference on Automation and Computation

Over 30 organizations of the learned-society pattern, including the three engineering institutions, constitute this Conference which, because the interests comprised in its field go beyond the purely technological sciences and include the economic and the sociological, has been organized in three Groups, as follows:

Group A—Engineering applications of automation
Group B—Computation and automatic control
Group C—Sociological and economic aspects of automation techniques.

The Institution of Mechanical Engineers acts as convener of Group A and provides its secretariat; The Institution acts similarly for Group B; for Group C, The British Institute of Management acts as convener. Mr. T. E. Goldup, C.B.E., IMMEDIATE PAST-PRESIDENT, has been re-elected Chairman of Group B: details of the Group's inauguration on the 20th December 1957 appeared in the *Journal* for January 1958.

40 British Council

Contact with the Science and Engineering and Visitors' Departments has continued, so that persons who visit this country under the auspices of the British Council and whose interests are in electrical engineering have the opportunity of visiting The Institution and of being invited to take part in its technical activities.

Sir Harold Bishop, C.B.E., B.SC.(ENG.), PAST-PRESIDENT, has succeeded Mr. T. G. N. Haldane, M.A., PAST-PRESIDENT, as the Council's representative on the Science Advisory Committee, and the Secretary of The Institution continues to serve on the Science and Engineering Panel.

The work of the Soviet Relations Committee of the British Council has again been supported (see par. 54).

41 British Standards Institution

The work of the British Standards Institution has been fully supported. Full details of the Council's nominations to the Engineering Divisional Council, the various Industry Standards Committees and many Technical Committees concerned with individual British Standards were published in the *Journal* for January 1959.

For the preparation of Codes of Practice, see par. 29.

For the British National Committee of the International Electrotechnical Commission, see par. 50.

42 Electrical Research Association

Support for the work of the Association has continued. Prof. J. Greig, M.SC., PH.D., MEMBER, and Mr. A. W. Montgomery, O.B.E., B.SC.TECH., MEMBER, serve on its Council as the nominees of the Council of The Institution.

43 National Inspection Council for Electrical Installation Contracting

The Institution's representatives on the Board of the National Inspection Council are Mr. S. E. Goodall, M.SC.(ENG.), F.Q.M.C., PRESIDENT, with Mr. R. A. Marryat, B.SC.(ENG.), MEMBER, as alternate, and Mr. Forbes Jackson, MEMBER, with Mr. S. J. Emerson, M.ENG., MEMBER, as alternate.

Mr. E. J. Sutton, MEMBER, Chief Technical Officer, serves on the Wiring Regulations Committee as the nominee of the National Inspection Council.

44 British National Committee for Non-Destructive Testing

The British National Committee for Non-Destructive Testing operates in collaboration with, but separately from, the Joint Committee on Materials and their Testing. On the nomination of the Council, Mr. C. G. Garton, MEMBER, serves on the British National Committee.

45 British Electrical Power Convention

The Council continue to support the British Electrical Power Convention and are represented on the Council of the Convention by Mr. R. W. Mountain, B.SC.(ENG.), MEMBER, with the Secretary acting as deputy.

46 British Association for the Advancement of Science

The Council have submitted replies to a questionary circulated by the British Association for the Advancement of Science in connection with the possible adoption in this country of a metric system and decimal coinage.

47 Conference of Commonwealth Engineering Institutions

The President (Mr. T. E. Goldup) and Secretary represented The Institution at meetings held in Australia from the 19th March to 1st April 1958. The 15 Recommendations and the 13 Resolutions of the Conference have been considered by the Council of The Institution who, in common with the Councils of the other constituent Institutions, unanimously approved the Recommendations and took note of the domestic Resolutions of the Conference.

A descriptive note on the work of the Conference appeared in the *Journal* for September 1958.

48 Eusec Conference of Representatives from the Engineering Societies of Western Europe and the United States of America

A meeting of the Conference, attended by the President (Mr. T. E. Goldup) and Secretary, was held in New York from the 28th April to 2nd May 1958. The 15 Resolutions and four Recommendations of the Conference have been approved by the Council of The Institution.

Personal impressions of the Eusec and Commonwealth Engineering Conferences were recorded by Mr. Goldup in Forewords which appeared in the *Journal* for August 1958.

49 South African Institute of Electrical Engineers

The Institution will be represented by the President and the Secretary at the celebrations to be held during September 1959 in South Africa to mark the Jubilee of the South African Institute of Electrical Engineers. On behalf of the Council they will be presenting the Council of the S.A.I.E.E. with a Corporate Seal in honour of the occasion.

50 International Electrotechnical Commission

The Institution's support of the work of the International Electrotechnical Commission has continued.

51 Commission Mixte Internationale

Mr. P. J. Ryle, B.SC.(ENG.), MEMBER, acts as the Council's representative on the Commission Mixte Internationale, which is concerned with studies for limiting the interaction of power and telecommunication systems.

52 World Power Conference

Mr. J. R. Beard, C.B.E., M.SC., PAST-PRESIDENT, serves as the Council's representative on the British National Committee of the Conference.

53 International Commission on Illumination (C.I.E.)

Through their adherence to the National Illumination Committee of Great Britain, the Council's support of the C.I.E. has continued.

54 Soviet Relations Committee of the British Council

In collaboration with this Committee, The Institution made arrangements for the reception of a team of six Soviet experts, specializing in the applications of automatic controls to industry, who visited this country from the 24th November to 6th December 1958. In the course of their tour they visited university laboratories, research establishments and industrial installations in London and the Provinces.

Arrangements were completed for a reciprocal visit of six British experts to the Soviet Union for a fortnight in May 1959.

SECTION E Education

55 Education and Training

The Council, through their Education and Training Committee, have been concerned with the rationalization of courses leading to the Higher National Certificate and Higher National Diploma in electrical engineering. Discussions took place between representatives of the Council and the Ministry, as a result of which a Joint Statement was issued in May 1958, referred to in par. 63.

Consideration has been given to eight courses in electrical engineering leading to the Diploma in Technology (Engineering), and in every case the Council have been able to grant complete exemption from the Institution Examination on the award of the Diploma. The first awards of the Diploma in Technology (Engineering) were announced during 1958, and these were made to electrical engineering students who had followed the course at the Birmingham College of Technology. The Council have noted that a Higher Award has now been introduced by the National Council to be known as a Membership of the College of Technologists (M.C.T.). The award will be made on the successful completion of a programme of work carried out jointly in industry and at a college.

A Joint Committee of The Institution and the British Institute of Management continued their meetings to discuss courses in management subjects, as a result of which it has been agreed that a course of the type suggested by the Committee should be provided in the University of Cambridge. It was hoped that this course could be started at Easter 1959, but this has been found to be impossible, and the start has, therefore, been delayed until the following year.

Further consideration was given to the education and training of student apprentices in electrical engineering, with particular reference to the increase which is taking place in industry-based sandwich diploma courses. A report was published under the authority of the Council in June 1958 and is referred to in par. 66.

The advisory service on education and training continues to provide answers to inquiries regarding careers in electrical engineering. A chart is given at par. 71 of this report showing that over a thousand letters were received asking for advice on education and training during the peak period in September 1958.

56 Joint Advisory Committee on Education (J.A.C.E.)

The Joint Committee continued the consideration of problems of education and training of common interest in civil, mechanical and electrical engineering. For example, the Joint Committee were asked to consider an inquiry from the Committee on Grants to Students set up by the Minister of Education and, after forming the view that there should be no parental means test attached to the award of such grants, advised the Councils of the three institutions, through their respective Education Committees, to reply separately on these lines.

The Commonwealth Engineering Conference held in Sydney in 1958 requested J.A.C.E. to act as a working party to maintain a continuous review of the education standards required of those proposing to enter the engineering profession in all countries of the constituent institutions of the Conference.

After consultation with the Ministry of Education, the Committee advised the Councils that, in their view, recent developments in the operation of National Certificate schemes in engineering pointed to the advisability of having direct technical college representation on the Joint Committee set up in each subject, to augment the nominations that had been made by the Councils from this field in the past. The Councils accepted these recommendations, and, in conjunction with the Ministry of Education, invitations have been issued to the appropriate associations to assist in filling two seats on each Joint Committee.

The Committee are currently engaged in assisting the Eusec Education Committee in compiling information on systems and standards of technological education in Western Europe and the United States of America, in continuation of the studies undertaken for the Paris Conference held in September 1957.

57 Eusec Conference on Engineering Education

The Report of the Third Eusec conference on the Education and training of professional engineers has now been published. The proceedings constitute a most comprehensive and authoritative exposition of engineering education in Western Europe and the United States. There remains, however, a large amount of supplementary work required to produce a complete account of engineering education in the several countries. To this end it was agreed, at a meeting of Eusec in New York in April 1958, to set up two working parties. The first will complete the diagrams and glossary illustrating engineering education contained in the Report of the Third conference, while the second will continue the general report. It is hoped to provide a fund of $48000 for this work. Financial support for the first stages of the project is being provided by a grant from the Ford Foundation, by the governing committee of the Office of Scientific and Technical Personnel of the O.E.E.C., and by contributions from the European member-societies of Eusec. It is hoped that, as the investigation proceeds, further contributions from O.E.E.C. and the Ford Foundation will be made available. The Eusec Working Party on Supply and Demand of Professional Engineers has terminated its study in view of the parallel investigation by O.E.E.C.

58 Higher Technological Education in India

H.M. Government have requested that British industry and the engineering institutions should join with them in supporting the proposed new College of Engineering and Technology at New Delhi. Funds for the maintenance of suitably qualified staff are being provided by the British Government, while industry has been asked to organize an appeal to raise an equal amount of money for the purchase of part of the necessary equipment. An appeal is being launched by the Federation of British Industries, and, as its purpose accords with the objects of the Charter of The Institution, the President has agreed to support it.

The College will cater for about 1250 students pursuing five-year courses in mechanical, civil, heavy and light electrical, and chemical engineering and will also provide postgraduate courses and facilities for research.

59 Examinations

A revised edition of the publication 'National Certificates in electrical engineering—lists of laboratory experiments' has been prepared and was published under the authority of the Council in May 1958.

A significant advance has been made in the recognition of degrees in electrical engineering awarded by universities in India and Pakistan. A candidate holding one of these degrees is now admitted without further preparation to Parts II and III of the Institution Examination and if successful is considered to have satisfied in full the educational requirements of The Institution.

The Examinations Committee have been engaged in a critical review of the syllabus for Part III of the Institution Examination. In this they have been assisted by the committees of the specialized Sections.

60 The Institution Examination

In 1958 the number of constituent members of the Engineering Institutions Examination Standing Committee for Part I was again increased by one when the Institution of Production Engineers joined the Committee. This now comprises eight institutions; otherwise the examination has remained unchanged.

There was a significant increase in the number of candidates taking the Part II Examination, this being mainly made up of candidates holding degrees in general science who were required to pass the two electrical engineering papers in Part II in addition to the Part III Examination.

The year 1958 was also the first occasion on which the Part III Examination was held at technical colleges in June and December. Arrangements were made for the submission of entry forms through the technical colleges at which candidates had prepared for the examination, with a slight reduction of examination fees for candidates entered collectively in this way. The colleges concerned also agreed to be responsible for the administration of the examination at the college. The June 1958 Examination was the first occasion on which candidates who had qualified for exemption from Parts I and II through National Certificate courses entered for the Part III Examination. It is expected that considerably more of these candidates will take the Part III Examination in 1959.

The reports on course-work in preparation for Part III of the Institution Examination indicate that while excellent laboratory facilities are being made available at some colleges there are a number where there is need for considerable improvement in laboratory work.

The number of candidates who presented themselves for examination in 1958 is given below. The figures for Part I in the Table include only those candidates seeking membership of The Institution.

	1958			
	April–June		*October–December*	
	Home	Abroad	Home	Abroad
Part I	52	108	55	29
Part II	108	66	79	26
Part III	181	39	77	—
English (at technical colleges) ..	5783	—	565	—

The English Examination for Part I, taken as an individual subject at technical colleges, was entered by 5783 candidates in April and by 565 in October 1958.

61 Theses

In the course of the year an unusually large number of candidates (15) have submitted theses for consideration in lieu of the Institution Examination. About half of these have been of high standard and have been accepted in satisfaction of the educational requirements, but of those rejected the majority failed completely to indicate the necessary level of educational attainment.

62 Common Preliminary Examination

During the year, 22 candidates presented themselves for the Common Preliminary Examination at home centres and 111 at centres abroad.

It has now been decided that the Engineering Joint Examinations Board shall be dissolved, and the Common Preliminary Examination will not therefore be held after 1960.

63 National Certificates and Diplomas in Electrical Engineering

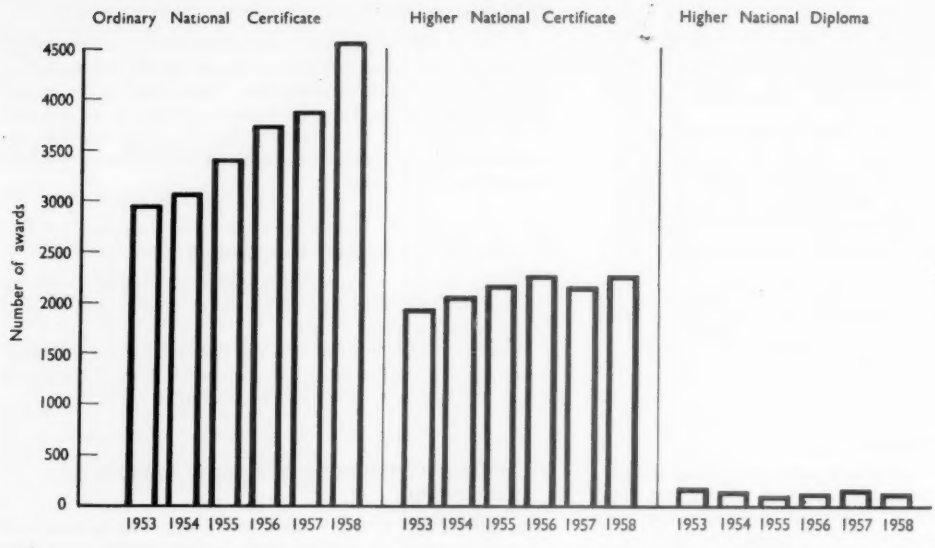
A Joint Statement by the Council and the Ministry of Education was issued in May 1958, dealing with the rationalization of Higher National Certificate and Diploma courses. In future, Higher National Diploma courses will be of three years' duration, preferably on the sandwich basis, from an agreed standard of entry and will be professional in character, designed to qualify for exemption from Parts I and II of the Institution Examination.

The Higher National Certificate courses will indicate the final qualification for a senior technician, and some courses, with this objective only in mind, will be approved by the Joint Committee where mathematics is not a final-year subject. Where the course is intended also to provide a route to professional qualification, the basic science endorsements must be completed before the candidate enters the final year of the Higher National Certificate course and will normally include mathematics as a final-year subject.

The Council, in association with the Ministry of Education for England and Wales, the Scottish Education Department, and the Ministry of Education for Northern Ireland, have been responsible for the award of National Certificates and Diplomas in electrical engineering to students who have successfully completed approved courses at 245 technical colleges in the United Kingdom.

The growth in the number of awards of National Certificates and Diplomas over the past six years is shown in Fig. 4.

During the year there has been a continued increase in the number of industry-based sandwich courses which have been approved for the award of the Higher National Diploma, and the number of student apprentices who obtain their professional educational qualification by this route or by other industry-based sandwich courses is expected to increase rapidly. The Higher National Certificate will eventually mainly serve the needs of senior technicians wishing to equip themselves for positions of greater responsibility. Developments may also be expected in short sandwich courses to provide a more thorough education for these senior technicians as an alternative to the Higher National Certificate courses. The Ordinary National Certificate is becoming of increasing importance as a stage in the examinations at which selection is made for student apprentices to proceed to courses leading to the Diploma in Technology (Engineering), to the Higher National Diploma or to the alternative



4 *National Certificates and Diplomas awarded*

part-time or sandwich routes leading to senior technician qualification.

64 Page Prize

The Page Prize, which takes the form of textbooks or instruments to the value of five guineas, is awarded each year to the candidate who is adjudged as having the best performance in the final examinations of the Higher National Certificate in electrical engineering.

In 1958 the Council awarded the Prize to Mr. P. R. Allcock, a day- and evening-class student at the Southend Municipal Technical College.

65 Scholarships

The Council have increased the value of Student Scholarships, and in 1959 they will consider for award four Research Scholarships at values from £100 to £500 per annum, two Graduate Scholarships at £400 and seven Student Scholarships at from £150 to £200 per annum.

During the 1957–58 Session a number of successes have been recorded from past Institution scholars which include a doctorate of philosophy, a first-class honours degree, and a first-class honours diploma in electrical engineering. The Scholarships Committee were also pleased to receive the reports of research work which had been successfully completed by two other scholarship holders.

66 Joint Committee on Practical Training

The Joint Committee on Practical Training in the Electrical Engineering Industry comprises members appointed by the Council of The Institution in consultation with the Council of the British Electrical and Allied Manufacturers' Association, the Radio Industry Council and other interested bodies.

The Joint Committee completed the preparation of a Report on the education and training of student apprentices in electrical engineering, which was published under the authority of the Council in June 1958. The Report, which is intended as a companion booklet to the Report on the training of graduates, recommends the industry-based sandwich diploma course as a preferred alternative to part-time study for student apprentices seeking professional qualifications. It was well received in the technical and educational Press and is achieving a wide circulation at home and oversea.

A conference was held at Savoy Place in November 1958 on group training, at which methods of organizing training for graduates or student apprentices within a group of engineering concerns each providing complementary portions of training were discussed.

67 Education Discussion Circle

There have been meetings of Education Discussion Circles in London, Birmingham and Leeds during the past ten years, supported not only by the staffs of universities and technical colleges but by members in industry who are interested in the education and training of electrical engineers. The Council have now approved the formation of a fourth Circle in the North-Western Centre.

The London Discussion Circle held eight meetings during the year, and the average attendance was 51. The subjects discussed have covered a wide range from 'The teaching of mathematics to engineers' to 'What is a cultured engineer?' In July 1958 members of the Circle visited the Clarendon Laboratories at Oxford and Blenheim Palace, and preliminary arrangements are now being made for the fifth exhibition of experimental apparatus for use in colleges, which will be held at The Polytechnic, Regent Street, London, in June 1959.

68 Careers Exhibitions

A number of careers exhibitions throughout the country have been supported during the year. Arrangements have been made, with the collaboration of local Centres, for exhibitions at Farnborough, Newport I.O.W., Keighley and Skipton, Farnworth and Birkenhead.

Careers conventions are becoming a regular feature in many schools, and there is a constant demand for careers literature for reference and display.

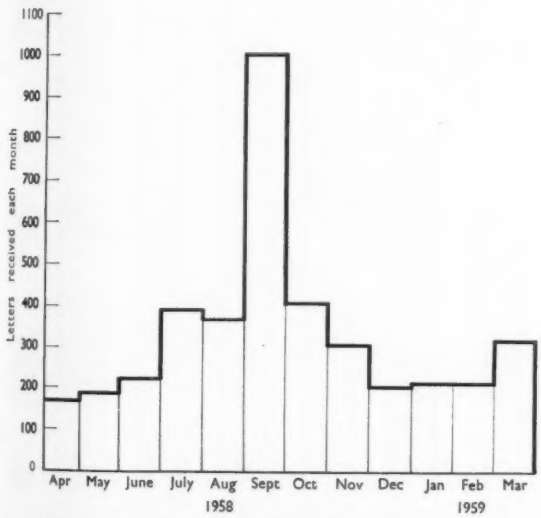
69 Reception for Oversea Graduates

In September 1958 the President (Mr. T. E. Goldup) received graduates from more than 30 oversea countries who had come to the United Kingdom for advanced studies or practical training in electrical engineering. Mr. Goldup welcomed the visitors and invited them to participate in the activities of The Institution during their stay in this country. A small exhibition had been arranged for the visitors, who also saw the film 'The inquisitive giant' showing the development of the radio telescope at Jodrell Bank. Members of Council and members of the Committee of the London Graduate and Student Section helped to entertain the visitors.

70 Oversea Visitors

Discussions took place in May 1958 jointly with representatives of the Institutions of Civil and of Mechanical Engineers and a Unesco Education Mission from Mexico. The visitors showed particular interest in the development of sandwich courses in the United Kingdom.

In July 1958 representatives from German technical universities visited The Institution for discussions, which were held jointly with The Institution of Mechanical Engineers, on the teaching of electrical and mechanical engineering. The visitors were interested in the complementary components of education and industrial training in the British system.



5 *Advisory Service on Education and Training*

71 Advisory Service on Education and Training

The Advisory Service is available to Government Departments and is used principally by the Ministry of Labour and National Service, from whom numerous inquiries are received concerning the deferment of call-up of electrical engineering students.

The facilities of the service continue to be used by Student and Graduate members, usually for advice about their educational qualifications and industrial training, and by others seeking advice on careers in electrical engineering. These letters are received throughout the year, but the incidence of inquiries is by no means constant as can be seen from Fig. 5.

72 Lectures for Young People

The title of this year's Christmas Holiday Lecture delivered by Dr. E. R. Laithwaite, M.SC., ASSOCIATE MEMBER, was 'Invention and new machines'. Over 700 school-children, including a large number of girls, attended the Lecture which was delivered in London on the afternoons of the 31st December 1958 and the 1st January 1959. Dr. Laithwaite also delivered the Lecture at Exeter on the 23rd December, at Salford on the 29th December, at Bolton on the 3rd January and at Manchester on the 10th January.

SECTION F Institution Library and Publications

73 Library

The main collection contains nearly 10000 books, over 11000 volumes of periodicals, reports, etc., and several thousand pamphlets. Over 560 current periodicals are being received.

The following statistics indicate the additions to the Library during the year, the use made of the Reference Library by members and non-members and the extent of borrowing from the Lending Library. Figures for 1957 are shown for comparison. Because of the work carried out in the summer the number of readers in 1958 is lower than average.

Reference Library

Year	Additions to the Library				Readers	
	Books		Pamphlets			
	Presented	Bought	Presented	Bought	Members	Non-members
1957	136	176	1057	123	8784	846
1958	156	145	1944	298	6579	560

Lending Library

Year	Books added to the Lending Library	Books issued	Borrowers' tickets issued
1957	122	5912	2200
1958	145	5052	2391

In addition, full use has been made of the facilities of the Science Library and Lewis's Library; the Science Library Photocopy Service has been used on 255 occasions. Particulars of the latter service have been published in the *Journal* (January 1959).

74 The *Journal* and *Proceedings* of The Institution

The *Journal* is supplied to all members, free of charge. The numbers of non-members who subscribed for the *Journal* and of members and non-members who subscribed for the *Proceedings* in 1958 are given below, together with the numbers of pages in the *Journal* and the three Parts of the *Proceedings*. Corresponding figures for 1957 are included for comparison.

	No. of pages		No. of members receiving copies		No. of non-member subscribers	
	1957	1958	1957	1958	1957	1958
Journal ..	682	708	All members		2084	1942
Proceedings:						
Part A ..	550	658	16683	16399	2088	2050
Part B ..	612	630	12095	11930	2772	2772
Part C ..	548	558	6850	6639	1890	1992
	1710	1846				

The numbers of papers published in the *Proceedings* during the six years 1953–58 are shown graphically in Fig. 6. Addresses, lectures and progress reviews are not included nor are the papers presented in connection with the following conventions and symposia, which were published in special issues as indicated.

Subject	Issue	No. of papers
Insulating materials	1953, **100**, Part IIA, No. 3	32
Electrical equipment of aircraft	1956, **103** A, Suppl. No. 1	20
Digital-computer techniques	1956, **103** B, Suppls. Nos. 1–3	55
Transatlantic telephone cable	1957, **104** B, Suppl. No. 4	11
Ferrites	1957, **104** B, Suppls. Nos. 5–7	47
Long-distance propagation above 30 Mc/s	1958, **105** B, Suppl. No. 8	23
Radio aids to aeronautical and marine navigation	1958, **105** B, Suppl. No. 9	18
Microwave valves	1958, **105** B, Suppls. Nos. 10–12	87

In addition, two papers on the position control of massive objects were published in 1958 in Part C, Suppl. No. 1.

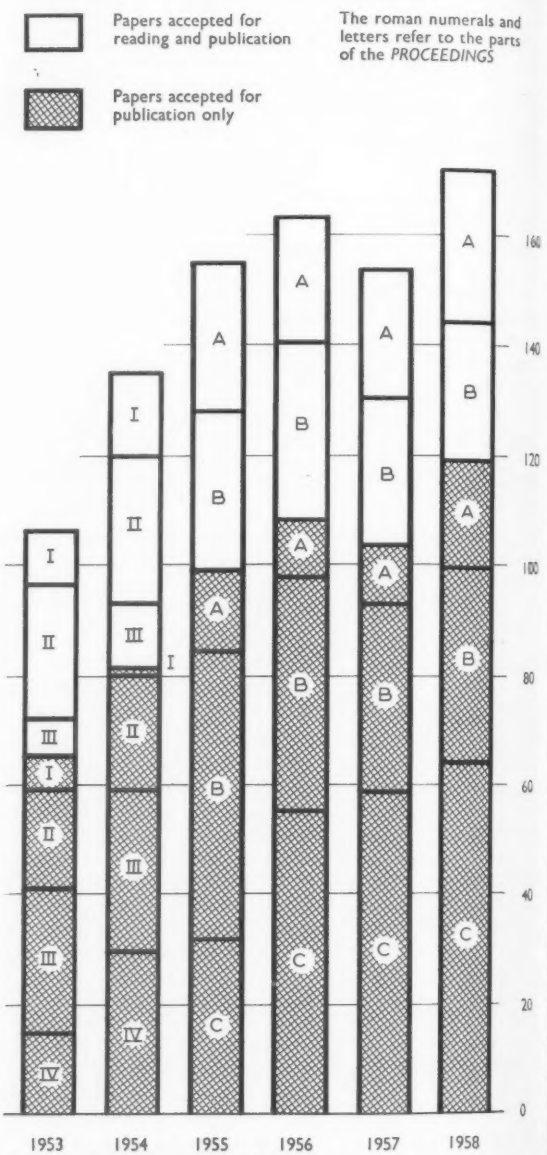
The results of the pilot inquiry among readers of the *Journal*, made in autumn 1957, have been carefully analysed. The Papers Committee asked the Committees of the local Centres and Sub-Centres and each Oversea Committee for their opinions on the main findings of the inquiry.

The feeling towards certain limited changes which was thus made evident was one of the three major influences impinging on the *Journal* during the year under review.

The other two were the increasing pressure on space in the *Journal* and the further development in electrical engineering as a whole of the trend towards a greater volume of publication of more and more highly specialized material.

All three influences push the same way—the *Journal*, in its task of providing a synoptic view of the whole field, must continue to improve its techniques of simple, nonspecialized exposition, of pruning and condensing all elaboration and verbosity, and of providing variety and attraction in presentation.

This is a continuing task, but some minor measures in this direction in the year under review included a reduction in the space devoted to individual obituaries, book reviews, and



6 *Numbers of papers published*

technical publications and in the type-size of certain reference features such as 'Forthcoming events', 'Contents of the current issues of the *Proceedings*', 'Library accessions', 'Papers and monographs published individually this month', and 'A review of the *Proceedings*'. There was a corresponding increase in the space given to those features generally agreed

in the pilot survey to be most useful, i.e. articles of general interest, phrased in simple technical language, and original technical articles.

In October 1958 the Bulletin of the Sections appeared in the *Journal* for the first time. Its aim is to provide better communication for the specialized interests of The Institution, and so far it is working satisfactorily. In January 1959 the *Journal* cover design was altered to include a photograph, changing with each issue.

Paper, Reprint and Monograph Services.—A paper accepted for reading at a meeting, like a monograph, is first published individually and republished in the *Proceedings* later. Reprints from the *Proceedings* of such papers, together with the discussions, and of papers accepted for publication only are also published. Particulars of the paper, reprint and monograph services are given in the *Journal* and also in the form of a leaflet which is distributed to non-members who subscribe to the *Proceedings* but not to the *Journal*.

75 *Students' Quarterly Journal*

The *Students' Quarterly Journal* continues to provide an outlet for technical papers, book reviews and correspondence from Graduate and Student members.

By means of quarterly reports from the 19 Sections, members are kept in touch with local activities.

The heavy increases in postage rates a year ago have been partly offset by a slight reduction in the number of pages, but despite this the material published continues to be over twice the pre-war quantity, reflecting correctly the great increase in Graduate and Student membership and activity.

76 Premiums

The Premiums awarded by the Council for papers read at meetings or accepted for publication only will be announced in the *Journal* during the summer of 1959.

On the recommendation of the Papers Committee, the Council have decided to discontinue the award of the Fahie, Paris Exhibition 1881 and Webber Premiums.

77 *Science Abstracts*

The number of abstracts published in Section A (Physics) in 1958 was 9201 compared with 10001 in 1957, the corresponding figures for Section B (Electrical Engineering) being 6434 in 1958 and 6451 in 1957.

78 Regulations for the Electrical Equipment of Buildings

Nearly 96000 copies of the 13th Edition of the Regulations, which was promulgated on the 1st September 1955, have been sold.

A second Edition of the Recommended practice for electrical installations in caravans, based on the Regulations and first issued in 1954, has been issued and has received wide support, nearly 3000 copies having been sold.

Amendments to the 13th Edition were approved by the Council having effect from the 15th December 1958. The amendments are occasioned primarily by changes in British Standards and in statutory regulations referred to in the 13th Edition, in particular by the issue of B.S. 3052—'Electric shaver supply units', the preparation of which was requested by the Wiring Regulations Committee. The amendments also incorporate a revised Regulation 507 and Note—Test of effectiveness of earthing, which has been prepared to take account of experience gained in the technique of earth-fault-loop testing. Copies of the 1958 amendments are obtainable separately from The Institution, price 1s. 6d., and over 12000 have been sold. Copies of the 13th Edition incorporating the 1958 amendments are also available, and the number of these sold has been included in the total of sales of the 13th Edition given above.

During the year the practice of publishing abstracts of those interpretations of the Regulations which raise clear-cut issues and are of general interest has continued, and four sets in all have been issued and published in the *Journal*, reprints being available from the Secretary.

Liaison is maintained with the British Standards Institution regarding British Standards cited in the Regulations, and a number of important draft Standards have been scrutinized from the aspects of safety from fire and shock. The technique of double insulation is receiving close attention.

79 Regulations for the Electrical Equipment of Ships

On behalf of the United Kingdom National Committee of the I.E.C., the Ship Regulations Committee acts as United Kingdom Committee for liaison with I.E.C. Technical Committee No. 18. The first Edition of an I.E.C. Code of recommended practice for electrical installations in ships was published in 1957. Outstanding matters to be dealt with in a proposed second Edition of the recommendations were considered at meetings held in Italy in May 1957 and in Konstanz, Germany, in June 1958. A number of items which were then deferred will be considered at a further meeting of the I.E.C. Technical Committee No. 18 to be held at Madrid in June 1959.

In 1956 the Council authorized the preparation of a fourth Edition of the Regulations for the electrical equipment of ships, to take the place of the third Edition (1939) with 1947 Supplement. Sub-Committees are nearing completion of the necessary technical investigations and drafting work, and their recommendations will go before the parent Committee in the near future.

SECTION G Benevolent Activities

80 Incorporated Benevolent Fund

The Report of the Court of Governors for the period 1st July 1957 to 30th June 1958, together with the Accounts, was circulated with the *Journal* for September 1958; a summary of the report was subsequently published in the *Journal* (November 1958, p. 623). Subscriptions and donations during the year showed an increase from £13765 to £15475. This welcome increase was largely attributable to the appeal circulated by the President with the December 1957 issue of the *Journal* which with other efforts, in addition to producing increased annual subscriptions, resulted in 350 new Deeds of Covenant, raising the Fund's annual income (with refund of income tax) by approximately £700. Seven legacies were received, amounting to nearly £900, and also the gift of royalties on a book.

Compared with last year, however, the expenditure has also increased, and this is partly due to the distributed grants having increased by nearly £800. The cost of grants plus

management and maintenance charges was £14707, and although this was a little less than the sum received from subscriptions and donations every effort must be made to continue to increase the income annually, as only by this means can the Court of Governors increase the assistance given to beneficiaries. It is particularly a matter for regret that there are many members of The Institution who make no contribution to the Fund; an annual donation of even a few shillings from each such member would result in a very substantial increase in revenue. Grants to 132 beneficiaries with 112 dependants amounted to £10506—an average amount of £80 per beneficiary.

The number of new cases (29) has increased considerably during the past 12 months, but this has been offset by the discontinuance of grants in 13 cases by reason either of death or of improvement in circumstances. Some of these latter beneficiaries had been in receipt of assistance for 25 years.

The Fund now has four beneficiaries resident in the Crossways Trust homes at West Worthing, Brighton and Englefield Green, and this collaboration has provided help for elderly people who are no longer able to cater for their own needs.

The total amount received in subscriptions and donations from the inception of the Homes Fund to the 30th June 1958 was £40493. The cost of erection of houses and flats on 'The Chesters' Estate, construction of the road and laying out of the grounds amounted to about £59500. All the occupants of the houses on the estate take great pleasure in their homes, and this is most rewarding to the Court. Members of the Fund can take justifiable pride in the wonderful results achieved by this scheme.

The Accounts of the Wilde Fund were published in the *Journal* (July 1958, p. 380).

Lord Hirst Fund.—This Fund exists to assist financially persons who apply for help and are recommended to the Trustees by the Court of Governors of the Benevolent Fund as deserving cases and as having rendered important services to electrical science, the electrical industry or electrical engineering. Assistance can also be given to the dependants of such persons.

On the 30th June 1958 the Fund comprised:

Capital account investments	£11543 3s. 10d.
Income account investments	£3989 11s. 2d.

which produce an annual income of about £627. The uninvested balance of the Income Account was £8 0s. 4d. Grants totalling £250 were made from this Fund during the year.

SECTION H Institution Staff

81 The Staff

The high standing of The Institution in national affairs, the continuing growth of its activities and the efficient manner in which these activities are conducted are due in very large measure to the devotion of the Secretary and his staff to their manifold duties and to the enthusiastic and co-operative spirit in which they approach them.

The Council wish to express their gratitude for the great service which the staff of The Institution have performed during the year on their behalf.

APPENDIX A

Membership of The Institution

The changes in membership since the 1st April are shown in the following Table:

1958	Hon. Mem.	Assoc. Mem.	Assoc. Com.	Assoc.	Grad.	Stud.	Totals
Totals at 1st April 1958 ..	17	4085	18777	77	2688	13786	3798	43228
Additions during the year:								
Elected	1	2	234	4	61	779	1269	2350
Reinstated ..	—	—	9	—	1	11	13	34
Transferred to	—	192	935	—	1	555	—	1683
Totals ..	1	194	1178	4	63	1345	1282	4067
Deductions during the year:								
Deceased ..	—	92	142	3	30	14	2	283
Resigned ..	—	3	46	1	41	64	75	230
Lapsed	—	6	53	1	20	130	333	543
Transferred from	—	—	191	—	11	908	573	1683
Totals ..	—	101	432	5	102	1116	983	2739
Net change ..	+1	+93	+746	−1	−39	+229	+299	+1328
Totals at 1st April 1959 ..	18	4178	19523	76	2649	14015	4097	44556

APPENDIX B

Growth of Membership over the last fifteen years

Year (31st March)	Corporate Members	Non-Corporate Members	Total Membership	Annual Increase
1945 ..	12573	14091	25665	2107
1946 ..	13447	15711	29158	2493
1947 ..	14501	16759	31260	2102
1948 ..	15206	17701	32907	1647
1949 ..	16027	18344	34371	1464
1950 ..	16648	18900	35548	1177
1951 ..	17146	19412	36558	1010
1952 ..	17757	19496	37253	695
1953 ..	18510	19272	37782	529
1954 ..	19552	18944	38496	714
1955 ..	20355	18943	39298	802
1956 ..	21089	18949	40038	740
1957 ..	22097	19425	41522	1484
1958 ..	22879	20349	43228	1706
1959 ..	23719	20837	44556	1328

APPENDIX C

Meetings

The following is a list of the meetings held during the 12 months ended 31st March 1959:

General Meetings	
Ordinary Meetings ..	10
Joint Meetings ..	1
Annual General Meeting	1
Annual General Meeting (Incorporated Benevolent Fund) ..	1
Electronics and Communications Section ..	50
Measurement and Control Section	20
Supply Section	9
c.f.	92

Council and Committee Meetings	
Council Meetings	10
London Committees	
Education and Training (and Panels)	19
Electronics and Communications Section (and Sub-Committees and Panels)	103
Engineering Institutions Examination Part I ..	4
c.f.	136

General Meetings	*b.f.*	92	
Utilization Section		8	
Informal Meetings		7	
Education Discussion Circle		8	
Medical Electronics Discussion Group		5	
Special Lecture		1	
District Meetings		21	
*Local Centres			
East Midland		16	(5)
Cambridge Electronics and Communications Group		7	(5)
Mersey and N. Wales		20	(8)
North-Eastern		20	(8)
Measurement and Electronics Group		10	(5)
North Midland		16	(8)
Utilization Group		5	(7)
North-Western		8	(9)
Electronics and Communications Group		5	(6)
Measurement and Control Group		5	(5)
Supply Group		5	(6)
Utilization Group		5	(6)
Northern Ireland		9	(6)
Scottish		—	(6)
South Midland		18	(5)
Electronics and Measurement Group		7	(6)
Supply and Utilization Group		5	(5)
Southern		29	(7)
Western		13	(8)
Supply Group		7	(4)
Utilization Group		6	(3)
*Local Sub-Centres			
East Anglian		17	(5)
North Lancashire		11	(8)
North Scotland		21	(9)
North Staffordshire		10	(9)
Rugby		11	(6)
Sheffield		12	(7)
South-East Scotland		21	(7)
South-West Scotland		20	(6)
South-Western		8	(6)
Tees-Side		8	(8)
West Wales (Swansea)		8	(7)
*Graduate and Student Sections			
Bristol		15	(4)
Cardiff		8	(10)
East Midland		10	(8)
London		23	(11)
Mersey and N. Wales		17	(9)
North-Eastern		11	(6)
North Midland		11	(7)
North Scotland		7	(2)
North Staffordshire		10	(9)
North-Western		10	(10)
Northern Ireland		7	(5)
Rugby		13	(8)
Sheffield		9	(9)
Southern		8	(4)
South-East Scotland		9	(6)
South Midland		14	(7)
South-West Scotland		8	(6)
Tees-Side		7	(7)
		702	(334)

Council and Committee Meetings	*b.f.*	136
London Committees—contd.		
Examinations (and Sub-Committees)		23
Finance (and Sub-Committees)		12
General Purposes (and Sub-Committees)		14
Hon. Secretaries' Conference:		
Local Centres and Sub-Centres		1
Graduate and Student Sections		1
Incorporated Benevolent Fund (and Sub-Committees)		11
Informal Meetings		3
Joint Committee on Model Forms of General Conditions of Contract (and Sub-Committees and Panels)		5
Joint Oversea Activities		2
Library and Museum		2
Local Centres		2
Measurement and Control Section (and Sub-Committees and Panels)		28
Membership (and Sub-Committees and Panels)		40
National Certificates		
England and Wales (and Sub-Committees and Panels)		11
Northern Ireland		1
Scotland		1
Oversea Activities		2
Papers (and Sub-Committees and Panels)		17
Regulations for the Electrical Equipment of Ships (and Sub-Committees)		11
Scholarships (and Panels)		3
Science Abstracts		3
Supply Section (and Sub-Committees)		14
U.K. Advisory on Ships (and Sub-Committees and Panels)		3
UtilizationSection(andSub-Committees and Panels)		19
Wiring Regulations (and Sub-Committees)		2
Other London Committees		8
Centres, Sub-Centres and Graduate and Student Section Committees (see details in parentheses in left-hand column)		334
		709

Also Code Drafting Committees convened for the Council for Codes of Practice	8
General Meetings	702
Council and Committees	709
Codes of Practice	8
Grand Total	1419

* The number of Committee meetings held is shown in each case in parentheses, and the total number of these Committee meetings is entered at the foot of the right-hand column

APPENDIX D

Index to the Report

Aircraft, Regulations for the Electrical Equipment of	*Par.* 31
Aircraft (Civil), Radio Equipment for	32
Annual Dinner	21
Benevolent Fund, Incorporated	80
British Association for the Advancement of Science	46
British Conference on Automation and Computation	39
British Council	40
British Electrical Power Convention	45
British National Committee for Non-Destructive Testing	44
British Nuclear Energy Conference	38
British Standards Institution	41
Buildings, Wiring Regulations for	78
Bye-Law Amendments	11
Careers Exhibitions	68
Chartered Electrical Engineer, Use of Designation	7
Codes of Practice	29
Commission Mixte Internationale	51
Common Preliminary Examination	62
Commonwealth Engineering Institutions, Conference of	47
Conversazione	20
Co-operation between Engineering Institutions	36
Deaths	5
District Meetings	17
Economic Commission for Europe	35
Education and Training	55
Education and Training, Advisory Service on	71
Education Discussion Circle	67
Education, Joint Advisory Committee on	56
Electrical Research Association	42
Electronics and Communications Section	13
Engineering Conference (Commonwealth)	47
Engineering Conference (Western Europe and U.S.A.)	48
Engineering Education, Eusec Conference on	57
Examinations	59, 60 and 62
Exhibitions of Outstanding Scientific Interest	24
Faraday House, Hampton Court Green	27
Faraday Lecture	12 and 23
Faraday Medal	3
Gift by the B.B.C.	28
Graduate and Student Sections	18
Higher Technological Education in India	58
Honorary Members	2
Honours and Distinctions conferred on Members	4
Illumination, International Commission on	53
Income Tax—Members' Subscriptions	9
Incorporated Benevolent Fund	80
India, Higher Technological Education in	58
Informal Meetings	14
Institution Building	25
Institution Examination	60
International Electrotechnical Commission	50
Joint Model Forms of General Conditions of Contract	33
Journal and *Proceedings*	74
Lectures for Young People	72
Library	73
Local Centres, Sub-Centres and Specialized Groups	16
Measurement and Control Section	13
Medical Electronics Discussion Group	15
Meetings	12–17 and Appendix C
Members' Subscriptions—Income Tax	9
Members who have Retired or who are of Long Standing	6
Membership	1 and Appendices A and B
National Certificates and Diplomas in Electrical Engineering	63
National Inspection Council for Electrical Installation Contracting	43
Oversea Activities	19
Oversea Graduates, Reception for	69
Oversea Visitors	70
Page Prize	64
Parliamentary and Scientific Committee	37
Practical Training, Joint Committee on	66
Premiums	76
Proceedings of The Institution	74
Professional Conduct	8
Radio Interference, Committee on	30
Rating Relief	26
Register	1
Scholarships	65
Science Abstracts	77
Ships' Electrical Equipment, Regulations for	79
South African Institute of Electrical Engineers	49
Soviet Relations Committee	54
Specialized Sections	13
Staff	81
Students' Quarterly Journal	75
Subscriptions and Entrance Fees—Revised Rates	10
Summer Meeting	22
Supply Section	13
Theses	61
Unauthorized Use of Membership Initials	8
Utilization Section	13
Wireless Telegraphy Act, 1949	34
Wiring Regulations (Buildings)	78
World Power Conference	52

ACCOUNTS FOR 1958

Income and Expenditure Account for the Year ended 31st December 1958

EXPENDITURE

Year ended 31 Dec. 1957		£	£	£
	MANAGEMENT:			
	Salaries, Wages and National Insurance	95,339		
	Staff Provident Scheme	7,218		
	Staff Canteen Subsidies	849		
	Printing, Stationery and Office Requisites	10,327		
	Postage of Correspondence and Notices	4,245		
	Telephone	1,521		
	Travelling Expenses	4,304		
			123,803	
	Less Charged to 'SCIENCE ABSTRACTS'		3,750	
111,883				120,053
	INSTITUTION BUILDING:			
	Ground Rent		2,201	
	Rates		6,113	
	Heating		2,767	
	Lighting and Power		952	
	Insurance		493	
	Household Requisites and Cleaning		3,968	
			16,494	
	Less Rents from Tenants	5,785		
	Charged to 'SCIENCE ABSTRACTS'	1,430		
			7,215	
9,319				9,279
2,097	FURNITURE AND FITTINGS (Repairs and Renewals)			2,079
	JOURNAL AND PROCEEDINGS:			
	Printing		43,227	
	Paper		29,473	
	Postage		21,864	
	Wrappers and Envelopes		914	
			95,478	
	Less Subscriptions	21,353		
	Sales and Advertisements	52,536		
			73,889	
27,793				21,589
2,155	STUDENTS' QUARTERLY JOURNAL (Editing, Printing, Postage, etc. *less* Sales)			2,707
639	LENDING LIBRARY (Books, Printing, Postage, etc.)			607
	'SCIENCE ABSTRACTS':			
	Block Contribution		2,933	
	Per Capita		1,676	
4,629				4,609
	INSTITUTION MEETINGS:			
	Advance Proofs		1,240	
	Reporting		550	
	London Graduate and Students' Section		634	
	Kelvin and Section Lectures		135	
	Refreshments, Assistance, etc.		1,147	
	Travelling Expenses of Authors of Papers		153	
	District Meetings		230	
3,866				4,089
	CONVENTIONS:			
	Symposium on Long-Distance Propagation		414	
	International Convention on Microwave Valves		2,071	
2,033				2,485
	LOCAL CENTRES:			
	Administration and Meetings Expenses		15,506	
	Travelling Expenses		341	
	Students' Lectures		240	
15,301				16,087
179,715			CARRIED FORWARD	183,584

EXPENDITURE—continued

£		£	£
179,715	BROUGHT FORWARD		183,584
	OVERSEA BRANCHES:		
	Administration Expenses	2,650	
	Loss on Exchange on remittances to London	731	
2,996			3,381
2,091	FARADAY AND CHILDREN'S LECTURES		1,989
438	PREMIUMS FOR PAPERS ETC.		357
1,870	SCHOLARSHIPS, provided from Institution Funds		1,890
	GRANTS:		
	Electrical Research Association	500	
	British Standards Institution	250	
	C.I.G.R.É.	75	
	Others	137	
999			962
	CONFERENCES:		
	British Electrical Power Convention	26	
	Commonwealth Engineering Conference—Sydney	2,142	
	Conference of Engineering Societies of Western Europe and U.S.A.	375	
368			2,543
1,333	PUBLIC RELATIONS ADVISER		667
516	ANNUAL DINNER		340
551	AUDIT FEE		551
605	LEGAL EXPENSES		406
—	CONVERSAZIONE		548
500	SPEAKING PORTRAITS		174
2,896	MISCELLANEOUS EXPENSES		3,495
8,544	TRANSFER TO REBUILDING RESERVE FUND		8,549
278	TRANSFER TO SINKING FUND (PREMIUMS for Redemption of Cost of Building and Lease)		278
	DEPRECIATION:		
	Library	774	
	Furniture, Fittings and Equipment	1,244	
1,904			2,018
205,604			211,732
1,187	EXCESS OF INCOME OVER EXPENDITURE TRANSFERRED TO BALANCE SHEET		5,057
£206,791			£216,789

INCOME

Year ended 31 Dec. 1957				
£		£	£	£
174,963	SUBSCRIPTIONS			184,063
5,804	ENTRANCE FEES			5,939
455	LIFE COMPOSITIONS			430
8,544	INTEREST ON INVESTMENTS			8,549
772	DEPOSIT INTEREST			617
2,009	MEMBERS' SUBSCRIPTIONS TO 'SCIENCE ABSTRACTS'			1,937
3,564	SALES OF 'MODEL GENERAL CONDITIONS', 'WIRING REGULATIONS', 'SHIP WIRING REGULATIONS' and 'HISTORY OF THE INSTITUTION'			4,325
	EXAMINATIONS:			
	Institution Examination (Candidates' Fees and Sale of Papers)	15,626		
	Less Examiners' Fees, Printing, etc. (but excluding cost of Administration and Overhead Expenses, approx. £8,500)	10,021		
			5,605	
	National Certificates and Diplomas (Candidates' and School Authorities' Fees)	10,439		
	Less Assessors' Fees, Stationery, Postage, Travelling Expenses, etc. (but excluding cost of Administration and Overhead Expenses, approx. £6,550)	6,556		
			3,883	
9,253				9,488
1,427	SALES OF CONVENTION PROCEEDINGS			1,077
—	CONVENTION ON RADIO AIDS TO AERONAUTICAL AND MARINE NAVIGATION			364
£206,791				£216,789

Balance Sheet, 31st December 1958

1957		£	£
£			
55,054	CREDITORS		80,051
19,302	SUBSCRIPTIONS ETC. RECEIVED IN ADVANCE		18,362
	REBUILDING RESERVE FUND:		
	Balance at 1st January 1958	226,108	
	Add Transfer from Income and Expenditure Account	8,549	
		234,657	
	Less Transfer to Surplus Account	9,868	
226,108			224,789
—	LEGACY FROM ESTATE OF THE LATE LT.-COL. J. P. O'GORMAN		2,000
903	RESERVE FOR CONTINGENCIES		903
26,447	RESERVE FUND FOR DEPRECIATION OF INSTITUTION BUILDING AND LEASE, BEING SURRENDER VALUE OF SINKING FUND POLICIES		27,495
	REPAIRS SUSPENSE ACCOUNT:		
	Balance at 1st January 1958	2,944	
	Less Expenditure on Repairs in 1958	1,634	
2,944			1,310
	Surplus of Assets over Liabilities:—Balance at 1st January 1958	72,085	
	Add Balance of excess of Income over Expenditure transferred	5,057	
	Transfer from Rebuilding Reserve Fund	9,868	
72,085			87,010
£402,843			£441,920

1957		£	£
£			
69,631	INSTITUTION BUILDINGS AND LEASE (at cost)	69,631	
	Add Part cost of reconstruction	9,868	
			79,499
26,447	SINKING FUND (Surrender Values of Policies for Redemption of Cost of Building and Lease)		27,495
	LIBRARY (exclusive of the Ronalds Library and Faraday Papers, which are held in trust, but inclusive of Thompson Library):		
	As per last Balance Sheet	7,448	
	Additions in 1958	1,292	
		8,740	
	Less Depreciation at 10% (excluding Thompson Library)	774	
7,448			7,966
	FURNITURE, FITTINGS AND EQUIPMENT:		
	As per last Balance Sheet	18,735	
	Additions in 1958	2,100	
		20,835	
	Less Depreciation	1,244	
18,735			19,591
17,544	DEBTORS		21,076
4,698	INSURANCE PREMIUMS AND SUNDRY PAYMENTS IN ADVANCE		4,746
15,883	STOCKS OF STATIONERY AND PAPER		12,028
	REBUILDING FUND. INVESTMENTS (at cost):		
	British Government Securities	127,613	
	British Municipal Securities	32,720	
	Dominion and Colonial Government Securities	40,568	
	Public Boards and Trade Facilities Stocks	9,798	
	Debenture Stocks	14,090	
226,108	(*Market value 31st December 1958*, £192,084: 1957, £181,351)		224,789
	GENERAL FUND INVESTMENTS. INVESTMENTS (at cost):		
9,617	British Government Securities		14,585
	(*Market value 31st December 1958*, £13,776: 1957, £8,174)		
1,508	CASH IN HANDS OF LOCAL CENTRES ON 31ST DECEMBER 1958		1,418
1,998	CASH IN HANDS OF OVERSEA BRANCHES ON 31ST DECEMBER 1958		2,322
345	CASH IN HANDS OF SECRETARY		330
2,881	CASH AT BANK		26,075
£402,843	ERNEST LEETE, *Honorary Treasurer* W. K. BRASHER, *Secretary*		£441,920

Report of the Auditors to the Members of The Institution of Electrical Engineers

We have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purposes of our audit. In our opinion proper books of account have been kept by The Institution so far as appears from our examination of those books. We have examined the above Balance Sheet and annexed Income and Expenditure account which are in agreement with the books of account. In our opinion and to the best of our information and according to the explanations given us the said accounts are properly drawn up and the Balance Sheet gives a true and fair view of the state of The Institution's affairs as at 31st December 1958. and the Income and Expenditure account gives a true and fair view of the excess of Income over Expenditure for the year ended on that date.

ALLEN, ATTFIELD AND CO., *Chartered Accountants*

17th March 1959

BLUMLEIN–BROWNE–WILLANS PREMIUM FUND

	£ s. d.		£ s. d.
Capital Account	700 0 0	Investment (at cost): £686 10s. 0d. British Electricity 4¼% Stock (1974–79)	700 0 0
	£700 0 0		£700 0 0

INCOME ACCOUNT	£ s. d.		£ s. d.
To Balance carried to Balance Sheet	105 17 6	By Balance (as per last Account)	76 14 0
		„ Interest received	29 3 6
	£105 17 6		£105 17 6

WILLIAM BEEDIE ESSON SCHOLARSHIP TRUST FUND

	£ s. d.		£ s. d.
Capital Account	2,808 12 6	Investments (at cost):	
		£1,755 15s. 6d. 3½% War Stock	1,853 2 6
		£200 New Zealand 3½% Stock (1963–66)	200 0 0
		£100 East Africa High Commission 3½% Stock (1966–68)	97 10 0
		£400 British Electricity 3½% Stock (1976–79)	396 0 0
		£250 Birmingham Corporation 2½% Stock (1966–71)	250 0 0
		Cash	12 0 0
	£2,808 12 6		£2,808 12 6

INCOME ACCOUNT	£ s. d.		£ s. d.
To Balance (as per last Account)	117 10 1	By Interest received	91 14 0
		„ Balance carried to Balance Sheet	25 16 1
	£117 10 1		£117 10 1

WILLIAM GEIPEL SCHOLARSHIP TRUST FUND

	£ s. d.		£ s. d.
Capital Account	1,292 18 1	Investment (at cost): £1,583 11s. 10d. 3½% War Stock	1,292 18 1
	£1,292 18 1		£1,292 18 1

INCOME ACCOUNT	£ s. d.		£ s. d.
To Amount paid to Scholar	50 0 0	By Balance (as per last Account)	66 13 4
„ Balance carried to Balance Sheet	72 1 10	„ Interest received	55 8 6
	£122 1 10		£122 1 10

DAVID HUGHES SCHOLARSHIP TRUST FUND

	£ s. d.		£ s. d.
Capital Account	2,000 0 0	Investment (at cost): £2,045 Metropolitan Water Board (Staines Reservoirs) 3% Guaranteed Debenture Stock (1922 or after)	1,998 15 0
		Cash	1 5 0
	£2,000 0 0		£2,000 0 0

INCOME ACCOUNT	£ s. d.		£ s. d.
To Amount paid to Scholars	60 0 0	By Balance (as per last Account)	175 16 0
„ Balance carried to Balance Sheet	177 3 0	„ Interest received	61 7 0
	£237 3 0		£237 3 0

HUNTER MEMORIAL LECTURE FUND

	£ s. d.		£ s. d.
Capital Account	350 0 0	Investment (at cost): £349 0s. 7d. 5½% Funding Stock (1982–84)	350 0 0
	£350 0 0		£350 0 0

INCOME ACCOUNT	£ s. d.		£ s. d.
To Balance carried to Balance Sheet	7 19 0	By Interest received	7 19 0

I.M.E.A. SCHOLARSHIP FUND

	£ s. d.		£ s. d.
Capital Account	15,202 0 11	Investments (at cost):	
		£5,965 5s. 10d. 3½% War Stock	5,965 5 10
		£4,500 3% Savings Bonds (1960–70)	4,500 0 0
		£1,867 0s. 9d. British Electricity 3% Stock (1974–77)	1,736 15 1
		£1,000 Bristol Corporation 3½% Stock (1961–66)	1,000 0 0
		£1,000 Coventry Corporation 3½% Stock (1960–64)	1,000 0 0
		£1,000 Paisley Corporation 3½% Stock (1958–60)	1,000 0 0
	£15,202 0 11		£15,202 0 11

INCOME ACCOUNT

	£ s. d.		£ s. d.
To Amount paid to Scholar	210 0 0	By Balance (as per last Account)	412 2 4
„ Balance carried to Balance Sheet	706 18 2	„ Interest received	504 15 10
	£916 18 2		£916 18 2

JOHN DOUGLAS KNIGHT AND ELIZABETH DUNCAN KNIGHT FUND

	£ s. d.		£ s. d.
Capital Account	980 2 9	Investments (transferred):	
		£333 6s. 8d. 3% Savings Bonds (1960–70)	333 6 8
		£624 9s. 6d. 3½% Conversion Stock	624 9 6
		Cash	22 6 7
	£980 2 9		£980 2 9

INCOME ACCOUNT

	£ s. d.		£ s. d.
To Amount paid to Scholar	30 0 0	By Balance (as per last Account)	51 2 0
„ Balance carried to Balance Sheet	52 19 0	„ Interest received	31 17 0
	£82 19 0		£82 19 0

SIR EDWARD MANVILLE SCHOLARSHIP FUND

	£ s. d.		£ s. d.
Capital Account	5,000 0 0	Investment (at cost):	
		£5,000 3% Savings Bonds (1955–65)	5,000 0 0
	£5,000 0 0		£5,000 0 0

INCOME ACCOUNT

	£ s. d.		£ s. d.
To Balance (as per last Account)	57 14 4	By Interest received	150 0 0
„ Amount paid to Scholar	150 0 0	„ Balance carried to Balance Sheet	57 14 4
	£207 14 4		£207 14 4

HENRY NIMMO PREMIUM FUND

	£ s. d.		£ s. d.
Capital Account	150 0 0	Investment (at cost):	
		£253 8s. 11d. 2½% Treasury Stock (1975 or after)	150 0 0
	£150 0 0		£150 0 0

INCOME ACCOUNT

	£ s. d.		£ s. d.
To Balance carried to Balance Sheet	6 6 8	By Interest received	6 6 8
	£6 6 8		£6 6 8

HENRY NIMMO PRIZE FUND

	£ s. d.		£ s. d.
Capital Account	500 0 0	Investment (at cost): £564 1s. 3d. British Electricity 4¼% Guaranteed Stock (1974–79)	500 0 0
	£500 0 0		£500 0 0

INCOME ACCOUNT

	£ s. d.		£ s. d.
To Balance carried to Balance Sheet	59 18 4	By Balance (as per last Account)	35 19 0
		„ Interest received	23 19 4
	£59 18 4		£59 18 4

PAGE PRIZE FUND

	£ s. d.		£ s. d.
Capital Account	100 19 5	Investments (at cost): £50 3½% War Stock	50 19 5
		£56 4s. 5d. British Electricity 3% Guaranteed Stock (1968–73)	50 0 0
	£100 19 5		£100 19 5

INCOME ACCOUNT

	£ s. d.		£ s. d.
To Award of Prize	4 0 8	By Balance (as per last Account)	12 0
		„ Interest received	3 8 8
	£4 0 8		£4 0 8

SIR CHARLES A. PARSONS MEMORIAL SCHOLARSHIP

INCOME ACCOUNT

	£ s. d.		£ s. d.
To Amount paid to Scholar	90 0 0	By Balance brought forward	111 4 6
„ Balance as per Bank Account	72 12 0	„ Interest received	51 7 6
	£162 12 0		£162 12 0

NOTE.—The Capital of this Fund is invested by the Charity Commission

PAUL SCHOLARSHIP FUND

	£ s. d.		£ s. d.
Capital Account	4,000 0 0	Investments (at cost): £3,019 3s. 7d. 3½% Funding Stock (1999–2004)	3,000 0 0
		£625 4% Funding Stock (1960–90)	500 0 0
		£562 4s. 7d. British Electricity 3% Guaranteed Stock (1968–73)	500 0 0
	£4,000 0 0		£4,000 0 0

INCOME ACCOUNT

	£ s. d.		£ s. d.
To Amount paid to Scholars	195 0 0	By Balance (as per last Account)	161 6 9
„ Balance carried to Balance Sheet	113 17 5	„ Interest received	147 10 8
	£308 17 5		£308 17 5

SALOMONS SCHOLARSHIP TRUST FUND

	£ s. d.		£ s. d.
Capital Account	2,044 15 4	Investment (at cost): £2,485 10s. 7d. Commonwealth of Australia 3% Stock (1972–74)	2,044 15 4
	£2,044 15 4		£2,044 15 4

INCOME ACCOUNT

	£ s. d.		£ s. d.
To Amount paid to Scholars	60 0 0	By Balance (as per last Account)	194 7 8
„ Balance carried to Balance Sheet	208 19 0	„ Interest received	74 11 4
	£268 19 0		£268 19 0

SWAN MEMORIAL SCHOLARSHIP FUND

	£ s. d.		£ s. d.
Capital Account	3,312 15 10	Investments (at cost):	
		£905 10s. 4d. 3% Savings Bonds (1960–70)	995 0 6
		£1,200 British Electricity 3½% Stock (1976–79)	1,194 4 0
		£1,135 17s. 9d. 3½% Conversion Stock (1961 or after)	1,123 11 4
	£3,312 15 10		£3,312 15 10

INCOME ACCOUNT

	£ s. d.		£ s. d.
To Amount paid to Scholar	210 0 0	By Balance (as per last Account)	316 17 1
„ Balance carried to Balance Sheet	215 15 7	„ Interest received	108 18 6
	£425 15 7		£425 15 7

THORROWGOOD SCHOLARSHIP TRUST FUND

	£ s. d.		£ s. d.
Capital Account	1,000 0 0	Investment (at cost):	
		£1,005 Agricultural Mortgage Corporation 5% Debenture Stock (1959–89)	1,000 0 0
	£1,000 0 0		£1,000 0 0

INCOME ACCOUNT

	£ s. d.		£ s. d.
To Amount paid to Scholars	62 10 0	By Balance (as per last Account)	88 4 11
„ Balance carried to Balance Sheet	75 19 11	„ Interest received	50 5 0
	£138 9 11		£138 9 11

WAR THANKSGIVING EDUCATION AND RESEARCH FUND (No. 1)

	£ s. d.		£ s. d.
Capital Account	1,700 0 0	Investment (at cost):	
		£2,000 3½% War Stock	1,700 0 0
	£1,700 0 0		£1,700 0 0

INCOME ACCOUNT

	£ s. d.		£ s. d.
To Balance carried to Balance Sheet	141 5 0	By Balance (as per last Account)	71 5 0
		„ Interest received	70 0 0
	£141 5 0		£141 5 0

WILDE BENEVOLENT TRUST FUND

	£ s. d.		£ s. d.
Capital Account	3,048 10 2	Investments (at cost):	
		£1,397 18s. 6d. British Transport 3% Guaranteed Stock (1978–88)	1,744 3 11
		£100 London County 2¾% Consolidated Stock (1960–70)	101 8 6
		£250 Commonwealth of Australia 3% Stock (1972–74)	250 0 0
		£500 3½% War Stock	501 9 3
		£381 15s. 1d. 4% Funding Stock (1960–90)	300 0 0
		£200 3½% Conversion Stock (1961 or after)	151 8 6
	£3,048 10 2		£3,048 10 2

INCOME ACCOUNT

	£ s. d.	£ s. d.		£ s. d.
To Grant authorized		102 0 0	By Balance (as per last Account)	45 13 6
„ Balance—Deposit Account	34 12 0		„ Interest received	94 2 2
Tax Recoverable	3 3 8			
		37 15 8		
		£139 15 8		£139 15 8

Electronic instruments in space-research vehicles

621.396.946: 621.317.7

Rockets and satellites, to say nothing of monkeys and mice, are leaving this earth with increasing regularity and accuracy, and it is timely to remember that every venture in the rapidly expanding science of space research is dependent on electronics. Use is frequently made of the latest technical developments, and new electronic research must often be instigated. In this article Dr. Boyd describes some rocket-borne instrumentation already developed for this branch of applied science. The author is in the Department of Physics, University College London.

R. L. F. BOYD, PH.D., ASSOCIATE MEMBER

THE exploration of space depends, like so much in science these days, on electronics. The early prophets of space research foresaw huge manned vehicles, carrying all that was necessary for human survival so that a man could explore space with little to aid him beyond his five senses.

Such has been the advance of science, however, that the data directly available to the senses represent only a tiny part of the total field of investigation. Electronic and instrument technology, keeping pace with scientific inquiry, have made it possible to study quantitatively and precisely a comprehensive range of phenomena encountered in space and in the upper atmosphere: a range which includes the whole of the electromagnetic spectrum from γ-rays to radio waves, electric, magnetic and gravitational field intensities, ions, atoms, molecules and interplanetary dust.

In addition to the basic detection and measurement there are the ancillary problems of finding the position, velocity and angular orientation of the vehicle, and of time-keeping, programming and data recovery. For their solution electronic techniques are employed, often in environments which are strange and stringent.

The environment

From the moment the motors of the propulsion system cease, the celestial laboratory finds itself in a condition of apparent weightlessness: only residual air-drag forces may give a barely perceptible acceleration field. With no gravity, instruments depending on a gravitational field for their proper action are therefore unsuitable.

The temperature in ordinary high-altitude sounding rockets does not attain equilibrium with the ambient radiation. For ground-launched vehicles this means that the most important factor is the initial passage through the atmosphere, which may heat the nose cone to several hundred degrees Centigrade on its outer surface. Added to the power dissipation of the instrumentation and conduction from the motor, this may result in a rising temperature for the equipment during flight. On the other hand, vehicles using liquefied gases as propellants may well provide a rather cold environment.

Equilibrium temperature

Only the smallest satellite vehicles suffer severe alternations of temperature on passing into and out of the shadow of the earth. Most vehicles settle down to a mean temperature that is very dependent on the nature of the shell's surface. For a deep-space probe, cooling can be quite a problem, especially if there is any appreciable internal energy source. Sputnik III had a special system of panels designed to maintain the correct temperature, while the Russian artificial planet had a carefully prepared surface and was separated from its final propulsion unit in an effort to keep the temperature near 20°C.

Erosion and poor manufacture or design could easily result in an equilibrium temperature differing by nearly 100°C from that intended. The bearing of this on such factors as the choice of insulating materials, the design of frequency- or gain-stable circuits, stabilization of power or voltage reference sources, the need for silicon transistors, and so on is obvious. Adequate safety factors are essential, since external conditions are only known in part and indeed may depend significantly on the closeness to which the intended trajectory is attained. Heat dissipation in the electronic equipment is not normally a problem—power is too precious.

Secondary cosmic rays produced in the structure of the vehicle would not normally damage electronic apparatus, but primary cosmic rays in regions of intense radiation like the Van Allen belt could reduce the efficiency of solar batteries or other exposed semiconductor devices after a few years' operation. Far more damaging, however, is interplanetary dust. Individual meteors are very unlikely to cause harm, but erosion by micrometeoric dust could reduce the transmission power of optical windows or disturb the radiation balance in a matter of months.

Electric fields in space are significant only in so far as they may result from electrostatic charging of the vehicle owing to ionization or photoemission from the

surface. There may be unwanted effects on certain instruments, particularly those concerned with ionization studies. There are magnetic fields in space trapped in clouds of highly conducting gas, and their study is a most important aspect of space research. The main problem is usually one of degaussing—how to measure the space fields without disturbance from the vehicle.

Corona discharges

Low ambient pressures in the near parts of the upper atmosphere seriously limit the power which can be used for telemetry because of corona discharges, although electrical breakdown is less of a problem at greater distances. Internal equipment is most commonly protected by pressurizing either the individual components or the whole chamber. Casting in epoxy resins is suitable for some types of equipment, though there may be rather a high weight penalty. (Occasionally casting alone is relied on to prevent corona.) For pressurization an inert gas may be chosen and (as in the Sputniks) stirred by a fan to increase the cooling.

The absence of convection cooling in a gravity-free environment is easily overlooked and is not easy to allow for in preparatory laboratory experiments.

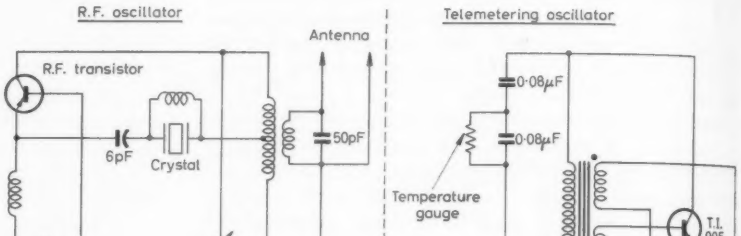
Mechanically the environment of the instrumentation in a probing vehicle is of the gentlest character, and quite flimsy inflatable satellites are planned. Conditions during launching, however, are very different, and equipment must pass stringent vibration and acceleration tests. For a small fast-burning rocket such as the 3in. balloon-launched Loki the steady acceleration reaches over 100*g*, but for larger systems it is less than 10*g*.

Often more serious are the vibrations due to the motor or to travel up a launching tower. These are important because mechanical damage may be done; errors may be introduced in the guidance and control systems; or the telemetering of behaviour during launching may be disturbed by noise due to vibration. In general, however, subminiature equipment has such a high strength/weight ratio that no special designs are required.

The power source

Fundamental to all electronic equipment is the power source. The cells most commonly used are silver–zinc and mercury–alkaline types and the Leclanché dry cell. All of these improve markedly in capacity as the temperature is increased. The first two give up to 40 or 50 watt-h/lb, while the Leclanché cell is only half as good. In a rocket carrying a number of experiments a motor alternator may be used to supply an alternating 'mains' voltage, which is then transformed and rectified as required, usually by semiconductor diodes. Alternatively, d.c. transformation may be carried out by transistorized multivibrator power packs.

The first serious use of solar cells was incorporated in the tiny Vanguard test sphere. This 4lb satellite carried six parallel-connected clusters, each providing 4·8 and 1·6 volts at 6·5mA. In optimum illumination conditions twice this output could be obtained, but if no storage batteries are carried a liberal surplus of power must be allowed. In a fully developed solar power system, diodes would be incorporated to prevent short-circuit of illuminated cells by non-illuminated ones, and for a vehicle spending part of its life in a planetary shadow storage batteries would be necessary.



1 *Beacon transmitter and telemetering oscillator for use in the microlock tracking and telemetering system*

Efficiencies up to 15% have been obtained, requiring at the earth's solar distance 50cm² per watt of peak power. In an unstabilized satellite four times this area must be allowed because of non-optimum illumination of some of the cells.

The weight of a solar-cell instrument is about 1lb/watt without storage batteries: with them this figure is approximately doubled. However, storage cells have a limited life. A typical lightweight system might last 100 days, after which the storage cells would be inoperative but the solar cells would continue to function while illuminated.

Quite recently research into atomic power sources has come to fruition. The basic principle of the recently announced American system, Snap III, is that of a thermopile energized by the heat produced from the radioactive decay of a suitable isotope, such as polonium

210 or cerium 124. Five watts are obtained from a source weighing about 5lb and lasting six months. The efficiency of the system is about 8%.

Efficient thermopiles may be built using certain semiconductors which give high e.m.f.'s, high electrical conductivity and low thermal conductivity, antimony and bismuth tellurides being a particularly good combination; but unfortunately semiconductors are rather susceptible to radiation damage.

A tiny prometheum battery designed to operate a watch gives over 10μA at 1 volt for 25 years using a photocell sandwich with a filling of a mixture of prometheum 147 and a phosphor. Alternatively, high voltages at low currents (e.g. 10kV at 10^{-10}amp) may be obtained simply by collecting β-rays from a suitable emitter such as strontium 90.

Recovery of data

Equal in importance to the power source is the data-recovery system. In single-stage rockets it is quite common to employ separate telemetering and tracking equipment. In satellites and deep-space probes, however, a unified system is almost invariably used, so as to make the most of the available power.

Tracking systems for satellites and deep-space probes do not normally employ there-and-back radio links. Position finding by the phase shift in the received signal can therefore be made absolute only if a very highly stabilized transmitter frequency is employed. This method has promise for deep-space probes, better than $\pm$1km error per hour of travel being practicable. The use of interferometer and, in general, radioastronomical techniques is, of course, normal.

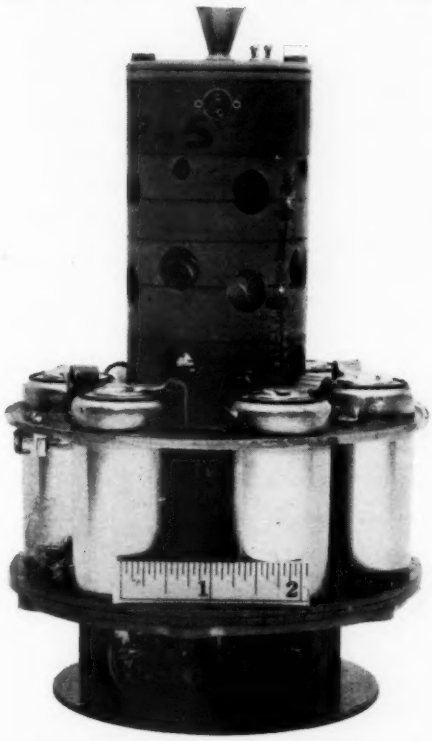
It is possible by using very-narrow-band radio links to operate satellite telemetry and tracking beacons on as little as 6mW. This is the power used in the American microlock system. So narrow is the r.f. bandwidth (10c/s) that a special phase-locked receiver is required to allow for the Doppler frequency shift as the satellite approaches and recedes. The solar-powered system for the Vanguard test sphere operates at 108Mc/s and employs a single silicon transistor for its r.f. output (see Fig. 1). A low-power transmitter unit for Explorers I and III is shown in Fig. 2.

A large variety of aerial systems is used. Most of the satellites have employed rods, the lower frequencies (20 and 40Mc/s) of the Sputniks demanding rather long unwieldly antennae folded back along the rocket for the initial launching. Sputnik III used loops. The Explorers have an insulating ring in the vehicle and excite the whole. The British Skylark high-altitude research rocket uses spikes for its telemetry and Doppler tracking transmitters and a microwave beacon with dielectric aerials for its primary missile-tracking system.

Frequency modulation, sometimes of a subcarrier, and pulse-position-modulation systems are most commonly used in telemetry, though the Sputniks used a telegraphic system with keying time ranging from 0·05 to 0·7sec. It is common for the transmitter to be switched cyclically either mechanically or electronically to perhaps a score of different inputs so that each channel is sampled, say, 100 times/sec. Analogue representation of data is still common, but binary digitalization is becoming more popular as giving a better data quality and ready feed to computers.

Determination of aspect

Determination of vehicle aspect may be important both for interpretation of scientific data from the sensing devices and, in the case of vehicles for launching satellites and deep-space probes, for guidance and control. A simple aspect-determination system used in Skylark involves measuring the direction of the sun (or moon) by photocells (whose output bears a known relationship to the angle between their normal and the solar vector) as well as the direction of the earth's magnetic field.

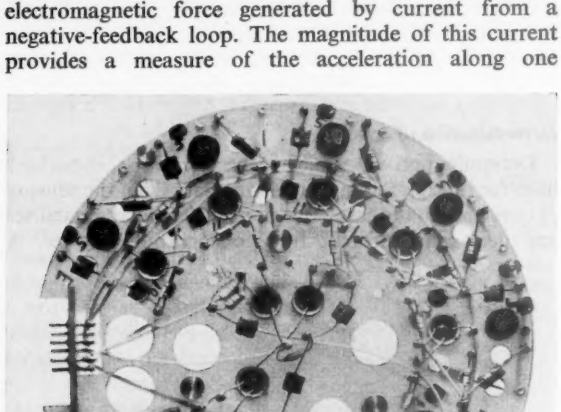


2 *Low-power transmitter unit for Explorers I and III*

The central cylinder, from the ruler up, contains the four subcarrier a.f. oscillators and their power supply. The lower section, below the batteries, is the transmitter. The transmitter batteries are sufficient for six weeks' operation

More sophisticated systems usually employ gyroscopes to give reference vectors. A rocket may be guided by a command radio link from the ground together with a suitable missile-tracking system. Where internal inertial guidance is employed, however, gyroscopes provide a stable platform on which the accelerometers are mounted.

A typical accelerometer employs a weight mounted on a spring and restored to its equilibrium position by an electromagnetic force generated by current from a negative-feedback loop. The magnitude of this current provides a measure of the acceleration along one



3 *Scaler deck for Explorer IV*

There are nine scaler stages around circumference and three output stages in centre. Scaler stages are bistable multivibrators operating over the ranges −50° to +100°C and 4·0 to 7·0 volts, at an input power of ¼mW/stage at 5·36 volts. Dead time can be made as short as 50 microsec
Approximately 6in. in diameter

direction co-ordinate, and after electronic integration (with respect to time) velocity and displacement may be extracted.

The basic instrumentation of upper-atmosphere rockets frequently includes recorders of one kind or another whose records are returned, usually with the whole nose cone, by parachute. In the Soviet Union considerable use has been made of the very simple procedure of ciné-photographing instrument dials in the instrument compartment. Notable use has been made of tape recording in the Explorer satellites. Here cosmic-ray data are recorded at ½-sec intervals during a 90-min orbit and are replayed over the telemetry on receipt of an interrogating signal from the minitrack receiving station.

Time-keeping is usually a basic requirement. In a simple experiment involving the ejection of a nose cone or of explosive grenades for sound-propagation experiments, the programme switch may consist simply of a d.c. electric motor run from a power source stabilized by a Zener diode, for example. Where more precision is required, a tuning fork may be employed as a standard.

Telemetry transmitters, for example the American microlock, are normally crystal-controlled. There is here an intrinsic time-reference of great stability, and countdown from this oscillator would provide timing more than adequate for most requirements. There can be little doubt, however, that progress in space research will eventually demand atomic time standards.

Ancillary electronic equipment

Amplifiers, scalers, discriminators and coders (see Figs. 3 and 4) are further examples of equipment for which a variety of experiments may have a common requirement. Transistors, printed circuits and sub-miniature components are usually employed, and the resulting flat assembly is dipped in an epoxy resin.

Transistors are particularly suitable in digital systems, where large numbers of components may be required and tolerances are usually large. Small currents down to about 1μA may be measured by silicon-transistor amplifiers, but if, as frequently happens, direct currents down to 10^{-10}amp must be measured the input stage must be a thermionic valve.

In addition to the basic scientific circuits both internal and external monitoring arrangements are frequently required. Internal monitoring involves such operations as the telemetering of h.t. supplies or oscillation amplitudes and the generation and switching of calibrating signals.

External monitoring involves the same, together with additional checks made by external equipment while the vehicle is in the test shop or on the launching pad. For non-orbiting vehicles it is during this period that the equipment receives its greatest use. It is quite inadequate to design, say, a motor-driven switch or potentiometer to last only the observing life of the rocket—probably less than 10min. Almost certainly it must last many hours of pre-flight testing of itself and of other equipment in the vehicle.

Sensing devices

The variety of sensing devices already employed in rockets and satellites is prodigious.

Radiation in the visible range is detected by photomultipliers or photocells. For a faint light like the fluorescence of the upper air, photomultipliers with a rotating system of interference filters give a series of readings in selected spectral bands. For an intense source, like the sun, a prism or grating spectrograph may disperse the light into a number of photocells, though more commonly photographic film is used and recovered. Systems of this kind frequently make use of a biaxial sunseeker—a system which keeps the slit of the spectrograph oriented towards the sun.

The first Pioneer shot at the moon sought to build up a television picture by scanning the lunar surface with a semiconductor photocell mounted at the focus of a mirror. The line scan was to be obtained as the vehicle rotated and the raster completed by the translational motion of the rocket. Unfortunately the moon was not reached. A similar system for exploring the earth's cloud cover is used in the meteorological Vanguard.

Pioneer III used a more sophisticated arrangement. The probing vehicle was given a slow roll, and a vidicon television tube was arranged to be exposed to the lunar surface once per revolution by a photoelectrically operated shutter. A magnetic-tape system recorded the data for transmission over the rather narrow-band 960 Mc/s telemetry link. The vehicle was again ill-fated.

At shorter wavelengths, in the ultraviolet and X-ray parts of the spectrum, the photons are proportionally more energetic. Use can therefore be made of ionization chambers and photon counters. These are devices similar to the chambers and counters of nuclear engineering but making use of the ionizing power of photons rather than of fast particles. The major problem in this work is the provision of suitable windows of material transparent to the photons. Currents are small so that, in the amplifiers of ion chambers, electrometer valves are commonly used.

Detectors for energetic corpuscular radiation include Geiger counters, scintillation counters and Čerenkov counters and even cloud chambers and β-ray spectrometers. Techniques are normal, though special systems may be used to make the maximum use of telemetry bandwidth when counting rate may vary or be uncertain over several decades. In one example not only was the counting rate telemetered but also the total current flow in the counter. In the event of saturation due to an unexpectedly high flux of ionizing particles the total ionization produced in the chamber would still give an estimate of the flux.

The need for this kind of precaution was dramatically demonstrated in the discovery of the Van Allen belt of radiation, several hundred times stronger than was expected. Initial estimates of its intensity had to be made simply from the fact that the counter had failed owing to saturation.

Pressure, density, and temperature

The measurement of pressure, density, and temperature can be carried out in many ways. External temperature in the upper atmosphere is best found from the velocity of sound. Internal and skin temperatures are monitored by thermistors. Internal pressures, and external pressures up to 30 miles altitude, are registered by diaphragm gauges.

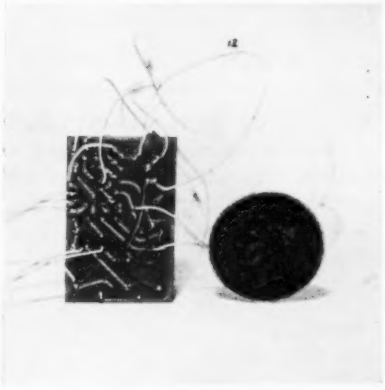
Above this height Pirani gauges are used. These rely on the dependence of cooling of a filament on the pressure of the surrounding gas. In their most satisfactory form a feedback amplifier maintains the resistance and hence temperature of the wire constant as the cooling varies. The power input (or voltage across the wire) is then a measure of the pressure. At lower pressures still (below 10^{-6} atm), pressure is found from the ionization produced by a beam of electrons or α-particles. A sensitive electronic amplifier is required.

Mass spectrometers identify the ions naturally present in the ionosphere by accelerating them through a potential of some hundreds of volts and then measuring their velocity as they pass through a series of grids actuated by an r.f. oscillator in such a way as to present a sequence of gates. Only ions whose mass bears a particular relation to the radio frequency and the accelerating potential are able to pass the gates and reach the collector. Analysis is accomplished by cyclically varying the radio frequency or the accelerating voltage.

The nature of the neutral atoms present in the atmosphere is found in a similar way after first ionizing them by a beam of electrons.

The apparatus for measuring the lunar and sub-lunar magnetic fields, developed for Pioneer, consisted of a coil rotating with the vehicle itself. A spin of several hundred r.p.m. was imparted to the vehicle before launching. One advantage of this system is that there is no magnetic disturbance from steady fields associated with the vehicle and its instruments, since these rotate with the coil.

Other methods, however, are capable of greater sensitivity. The first detection of the equatorial electrojet current in the E-layer was made with a flux-gate magnetometer flown in an Aerobee. More recently much use has been made of proton free-precession magnetometers. These have the advantage that the data are obtained as a frequency which is proportional to the total magnetic field. The angle between the axis of the detector and the field vector affects only the amplitude of the signal, not the frequency. Freedom from the influence of the vehicular field is obtained by ejection of the magnetometer on a flexible lead.

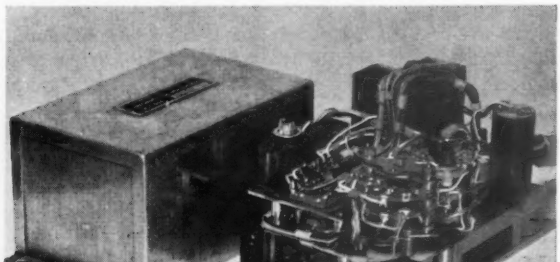


4 *Underside of transistor amplifier for Skylark ionosphere probe, showing printed circuit*

Interplanetary dust

Much effort has been put into the study of interplanetary dust, and a lot of information has been obtained, though unexplained inconsistencies are still serious. The simplest detector consists of a crystal microphone attached to part of the shell of a rocket or satellite feeding an amplifier tuned to a frequency around 50 kc/s.

Such a system will detect particles a few thousandths of a millimetre in diameter, but it has the disadvantage that internal creaks and noises are not distinguished. A more satisfactory arrangement employs two microphones. Internal noises affect both, but a micrometeor only strikes one at a time. An anti-coincidence circuit rejects the coincident counts.



5 *Electronic unit for Skylark ionospheric probe*

The unit comprises:

Solenoidal switch
Motor-driven potentiometer to give sawtooth voltage on probe
Motor-driven range-change switch
Two electrometer-valve preamplifiers
Two 2-stage symmetrical transistor amplifiers
Two inductors for modulating the telemetering frequency
Calibrating unit

The cover measures 3¼ × 3¼ × 5½in.

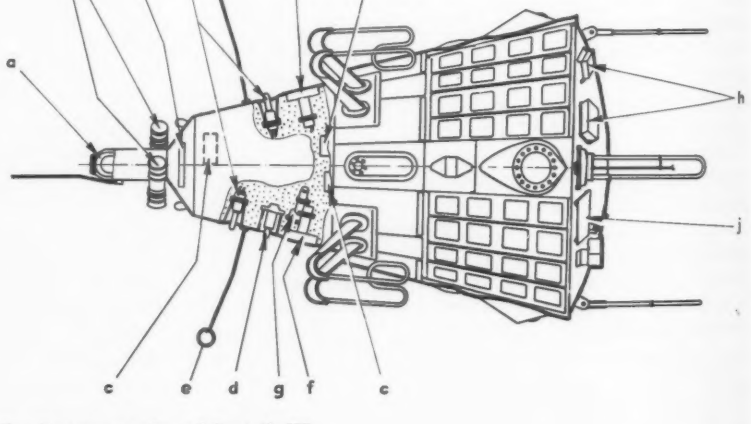
Other devices for detecting micrometeors include: pressure gauges to monitor internal pressure and so detect skin penetration; thin chromium strips evaporated on glass, whose resistance rises under the eroding action of impacts; and photocells 'looking' through foil strips whose penetration may thus be revealed by the signal from the photocell.

Much may be learnt about the ionization in the upper atmosphere and interplanetary space from the currents collected by a probing electrode thrust out from the rocket or satellite. Skylark employs systems of this kind to determine the concentration of electrons and ions in the ionosphere, special interest attaching to the concentration of heavy negative ions in the D-layer and to the thickness of those thin irregular patches of ionization known as sporadic-E. (The electronic unit for Skylark is shown in Fig. 5.)

Sputnik III (see Fig. 6) used somewhat similar equipment to measure ion concentrations at greater heights

Table 1. Typical payloads

Vehicle	Total payload weight, lb	Typical instrumentation
Loki balloon-launched rocket	8½	Cosmic-ray Geiger counter Telemetry
Skylark	150	Photomultiplier for Airglow Solar X-ray detectors Aspect indicators Sporadic-E ionization probe Pressure gauges Telemetry
Russian meteorological rocket	150	Pressure gauges Solar-radiation bolometer Resistance thermometer Photographic recorder
Explorer I	18	Cosmic-ray Geiger counter Skin- and internal-temperature gauges Micrometeor-erosion gauges Two telemetry transmitters
Sputnik III	2240	Magnetometer Ionization pressure gauges Ionization probes Electric fluxmeters Mass spectrometer Micrometeor microphones Solar batteries (on test) Four distinct systems for the study of cosmic and solar corpuscular radiation Telemetry
Russian artificial planet	800	Triaxial magnetometer Several cosmic-ray detectors Source of sodium vapour to provide a celestial marker Ionization probes Micrometeor microphones Telemetry
Pioneer IV (American artificial planet)	8	Cosmic-ray detectors Photodetectors for moonshine Telemetry



6 *Instrumentation of Sputnik III*

a Magnetometer **b** Photon counters or ionization chambers **c** Cosmic-ray instruments **d** Ionization gauges **e** Ion traps **f** Electrostatic voltmeter **g** Mass spectrometer **h** Micrometeor microphones **j** Solar batteries

in the upper F-regions. Methods of this kind are also capable of yielding information about the temperature of the electrons in the ionosphere.

Some typical payloads

High-altitude research is expensive. From several points of view it is desirable to press miniaturization to the limit so as to pack as much as possible in any one vehicle. There are however three opposing factors: first, compatibility—different rocket experiments require different times of launching; satellite experiments require a variety of orbits; high-power telemetry may upset radiation measurements; and so on.

Secondly preparation and co-ordination problems and the time involved rise rapidly as complexity of instrumentation increases. After a time, protracted periods of preparation and testing and repeated count-downs reduce the over-all reliability. Thirdly telemetry information space is always at a premium. It is useless to install more instruments than the telemetry can adequately cope with.

These considerations apply to any given vehicle. There may also be a choice of vehicle. The Americans have excelled in miniaturization and the optimum use of minimal systems. Very good work has been done with the 3in.-diameter Loki launched from a balloon and costing in all only a few hundred pounds. Vanguard, weighing only 12 tons, is at last coming into its own as a satellite system.

It may be very convenient to launch a ton of equipment, but the nature of electronics is such that it is questionable whether it is desirable to use such immense loads for near satellites unless they are demanded by mechanical considerations such as aspect stabilization or the mounting of an astronomical telescope. Table 1 shows some characteristic payloads.

For deep-space probes the overriding consideration is the communication link, and every effort must be made to provide adequate radio power for a long period. Perhaps the major contribution which the advancing technology of electronics must make to space exploration is the minimization of power consumption and the improvement of power sources and of radio telemetry. Communication with distant vehicles is undoubtedly the biggest problem of the immediate future.

Summary

The most important of the special environmental conditions for electronic instruments in satellites is temperature. This is closely followed in significance by vibration and acceleration hazards and by weightlessness. None of these conditions is normally serious for miniature equipment. Miniaturization is as important in connection with power saving and strength as in space and weight economy. The provision of electrical power is a major, if not limiting problem for much satellite experimentation.

Types of power source available are discussed, as is the ancillary equipment normally required in space vehicles for data recovery, position determination, time-keeping and so on. Also briefly mentioned are the many types of sensing device with which basic measurements are made.

Television film by transatlantic cable

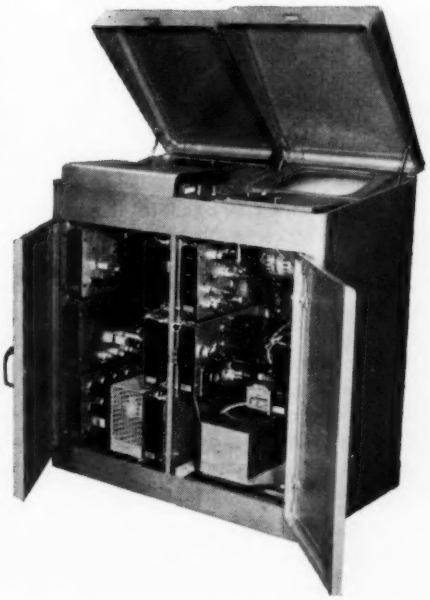
THE B.B.C. have developed a system whereby news flashes of important events can be exchanged between the North American and European continents within a few hours of their occurrence.

The film sequence to be transmitted is scanned by a low-speed flying-spot scanner whose video signals are used to modulate a 5kc/s carrier for transmission over a 'music' channel of the transatlantic telephone cable. At the receiving end the signals after demodulation are used to operate a low-speed film telerecording apparatus. (Identical film equipments are used at both terminals, working as either a flying-spot scanner or a telerecording channel.) A lecture on 'Transmission of news film over the transatlantic cable' by C. B. B. Wood and I. J. Shelley will be given at an Ordinary Meeting at Savoy Place, on the 22nd October, 1959.

The cable channel used has a nominal bandwidth of 6·4kc/s, but it is necessary to restrict the video frequency to 4·5kc/s. To achieve this compression a number of economies are made, compatible with accepted picture quality. The horizontal definition is made to correspond to a bandwidth of 1·75Mc/s in the 405-line television system; only 200 lines are scanned (sequentially); and at the transmitting end only alternate film frames are scanned, with each frame scan reproduced on two adjacent film frames at the receiving end. For rapidly moving subjects which would give 'jerky' pictures provision is made for transmitting every frame of the original film, but this of course doubles the transmission time and cost.

By these means the 3Mc/s bandwidth of the British television system is reduced to 450kc/s, the remainder of the reduction being obtained by decreasing the scanning speed. Thus it takes 100 times longer than normal to scan the film, e.g. about 50min to transmit a half-minute news flash from Montreal to London.

The illustration shows the film-scanning equipment with the doors open to reveal the electronic chassis.



Electrical supplies to power-station auxiliaries

This brief article is based on a Supply Section paper (2759) with the above title by D. A. Dewison, Associate Member. The paper was published individually in December 1958 and will be republished in Part A of the Proceedings. The author is with the Central Electricity Generating Board.*

THE electrical supply to power-station auxiliaries is an important part of the efficient and reliable operation of a power station, and careful consideration has to be given to the design of the electrical system. A system has to be provided which gives adequate power to drive the auxiliaries, with the connections arranged in such a manner as to give the greatest reliability consistent with a reasonable cost.

Improving reliability

One of the factors in improving reliability is to design from the outset as simply as possible so that operators can readily visualize the system at any time, thus reducing the possibility of maloperation to a minimum.

The power consumed by electrical auxiliaries is of the order of 4–7% of the station output for conventional coal-fired stations; nuclear stations require considerably more power than this.

Various methods of connection have been tried, but the one almost exclusively used at present is the unit-transformer system which is ideally suited to the unit principle of power-station design where one boiler and one turbine run as an entirely separate unit in a multi-unit station.

The unit-transformer system

Fig. 1 illustrates a distribution system for a power station comprising five 200 MW units. Two sources of supply are provided: one from the station transformers, which are connected to the Grid system, and the other from the unit transformers, which are connected to the terminals of the generators.

The auxiliaries connected to the unit transformers are 'urgent' auxiliaries, i.e. those whose breakdown might cause a loss of output from the station.

An interconnection is provided between the station boards and the unit boards for starting purposes and as an emergency standby supply in the event of failure of the unit supplies.

The auxiliaries connected to the station transformers are 'service' auxiliaries, i.e. those whose breakdown would not affect the output of the station until after a considerable time. Included in this group are those auxiliaries which, although associated with a unit, are not urgent, e.g. the barring gear which is used for starting up the unit.

* This article and the following one are based on, and written by the authors of, current Institution papers. The authors have been asked to make these articles so far as possible interesting and of appeal to electrical engineers who have no specialized knowledge of the subjects, and the content of the articles is not neccessarily confined to the subject-matter of the original papers

Safety arrangements

The arrangement of connections is such that paralleling can be made only at the 6·6 kV switchgear; this operation can therefore be carried out only by an experienced operator. It is impossible to parallel at the 415-volt level.

The standby boiler-feed pump and booster pumps are special auxiliaries and are connected so that only a failure of both the unit and the station supply sources occurring simultaneously can cause the boiler-feed water to be lost. Facilities are provided for transferring these auxiliaries from the station supply to the unit supply when they have come into operation.

The reactor shown connected between the two station transformers is incorporated to reduce the fault-level rating of the switchgear, and interlocking is provided to ensure that the two transformers cannot be paralleled unless the reactor is inserted.

When starting up a unit a supply is taken from the station transformer to the unit board and the unit brought up to speed, synchronized with the Grid and very lightly loaded. The unit transformer and station transformer are check-synchronized and paralleled. The station transformer is tripped out, leaving the auxiliaries supplied from the unit transformer. The process is reversed when shutting down the unit.

Classification of auxiliaries

In order to determine whether an auxiliary should be classified as 'urgent' or 'service' it is necessary to examine its function and appreciate its relative importance. Fig. 1 illustrates how the auxiliaries have been classified for a typical station.

Choice of voltage

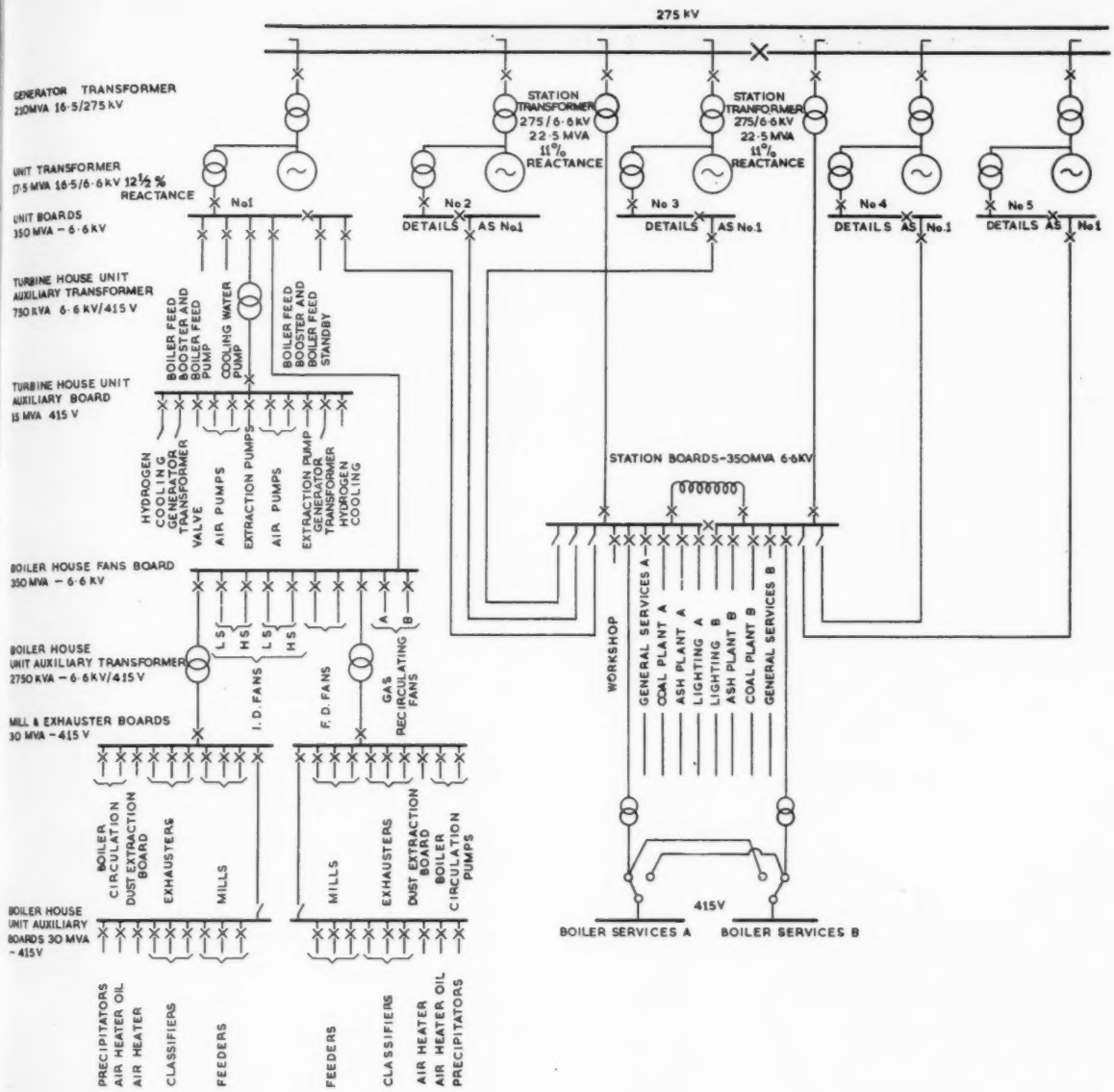
The auxiliary loading on modern stations results in currents too great to be supplied at the normal industrial voltage of 415 volts. Most stations use 3·3 kV, but recent designs have required 6·6 kV, and for very large stations 11 kV becomes necessary. These higher voltages step down to 415 volts for the smaller auxiliaries.

In specifications for major items of plant used at a power station there is a clause specifying the voltage to be used for the motors.

The following are the standards used by the C.E.G.B. at the present time:

Where the main voltage is 3·3 kV—motors up to 150 h.p. to be at 415 volts
Where the main voltage is 6·6 kV—motors up to 300 h.p. to be at 415 volts.

These standards have not been strictly adhered to in all



1 *Auxiliary power-supply connections for five 200 MW units*

cases as there may be advantages in going outside these limits in certain circumstances.

No standards have been laid down for 11 kV, but it is considered undesirable to have motors much below 1000 h.p. for this voltage.

Parameters of system design

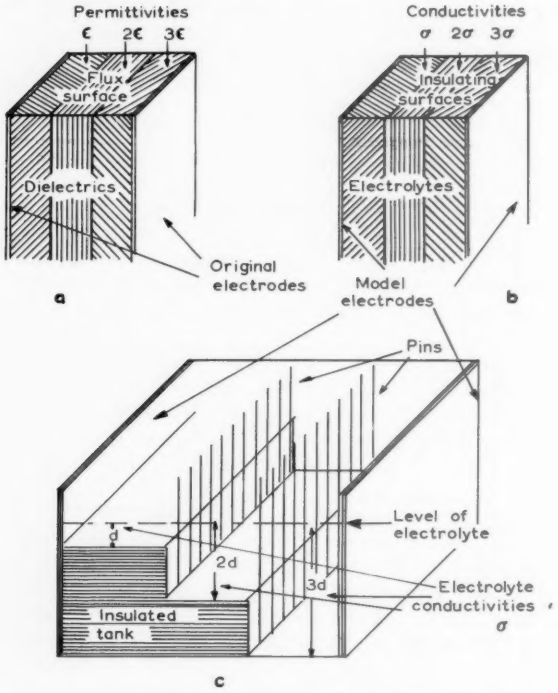
The design of the distribution system requires the integration of a number of factors, namely choice of voltage, switchgear rating, loads, voltage regulation and economics. An important aspect of the design is the impedance of the station and unit transformers, as this governs the MVA rating of the switchgear and the voltage regulation of the system. It is desirable to keep the switchgear rating down since the higher the rating the higher is the cost. In order to do this it is necessary to have a high impedance in the transformers.

Unfortunately this requirement conflicts with the desirability of having good regulation, because the higher the impedance the greater the voltage drop. Much study is needed to determine the most satisfactory compromise between these conflicting requirements. 621.311.8

Representation by electrolytic tank

A brief account based on a Graduate and Student Section paper entitled 'The electrolytic tank and the use of a self-balancing bridge' by D. Chandra, B.Sc., Graduate. The paper is the Chairman's Address to the South-East Scotland Graduate and Student Section delivered at Edinburgh on the 7th October 1957, and it was awarded a Premium by the Council. The author was formerly with Bruce Peebles and Co. Ltd. and is now with the Prem Engineering Co., Godowlia, Varanasi, India.

In the design of high-voltage equipment electrostatic problems are of major interest. Analytical solution is extremely difficult, but solution by experiment in one of the analogues of the system is comparatively simple.



1 *Representation of a two-dimensional heterogeneous-dielectric problem in an electrolytic tank*

a Original system **b** Direct analogue
c Practical analogue

One experimental analogue method involves the use of an electrolytic tank, and an instrument has been developed for making measurements within the tank.

Principle and application of the electrolytic tank

The basis of the analogy lies in the fact that fields such as conduction, magnetic, electrostatic or fluid flow are expressed in mathematically similar terms and stem from either Laplace's equation or Poisson's equation. Thus the experimental field pattern established for one applies to all fields with like conditions and geometry.

In the electrolytic tank, measurements are taken in a conduction-field analogue of the electrostatic problems to be solved.

Two-dimensional homogeneous dielectric

By comparing two plates separated by a homogeneous dielectric with two plates separated by an electrolyte we can tabulate the analogies between the parameters of the two systems. If A is the area of each plate and l is the distance between them in each case, the correspondence is as follows:

Electric field	*Conduction field*
Capacitance $= \frac{\Psi}{V} = \frac{Da}{El} = \frac{\epsilon a}{l}$	Conductance $= \frac{I}{V} = \frac{Ja}{El} = \frac{\sigma a}{l}$
Permittivity $= \epsilon$	Conductivity $= \sigma$
Flux surfaces	Insulating surfaces
Tube of force	Tube of current

Two-dimensional heterogeneous dielectric

When there is more than one dielectric between the parallel plates as shown in Fig. 1a, three permittivities ϵ, 2ϵ and 3ϵ can be represented by conductivities σ, 2σ and 3σ as in Fig. 1b. It is more practical, however, to vary the depth of the electrolyte in the ratio of d, $2d$, and $3d$ as shown in Fig. 1c.

To obtain sharply defined zones and so represent abrupt changes in permittivity, rows of conducting pins are inserted at inter-zone boundaries.

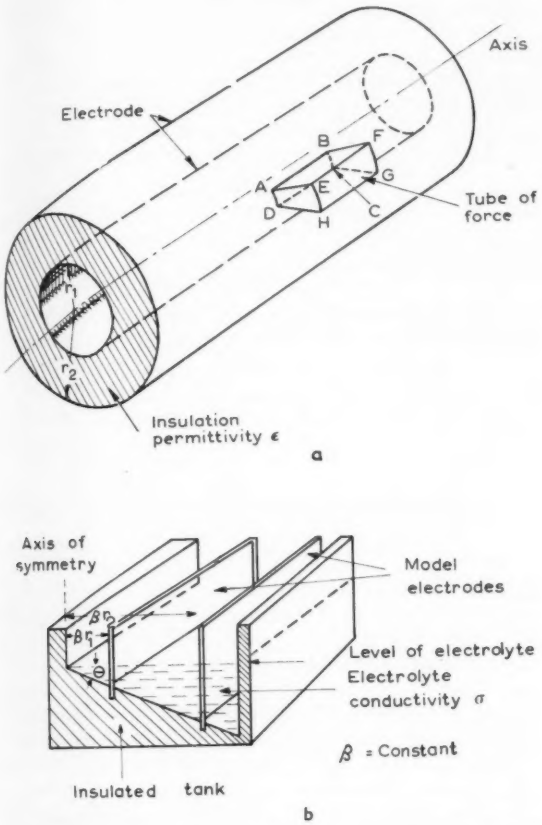
Three-dimensional problems

In two-dimensional problems third-dimensional or 'end' effects are neglected, but in three-dimensional fields the end effects are significant and all electrodes are finite. It is therefore very difficult to represent ordinary problems in three dimensions unless they have circular symmetry, when it is possible to devise a simple and exact analogy.

Consider the tube of electric flux in the circular-symmetry problem shown in Fig. 2. It is prismatic, and the flux surfaces ABFE and DCGH bounding it meet at the axis. To produce a current tube similar to this in the electrolytic tank its bottom is tilted, making the insulating surfaces the bottom of the tank and the free surfaces of the electrolyte. Theoretically the electrodes should be curved, but by keeping θ small they may be considered flat. Fig. 2 shows the analogue model of a three-dimensional homogeneous-dielectric problem.

A typical three-dimensional circular-symmetry problem arises in the study of surge distribution in transformer windings. When a lightning surge strikes a transformer, the voltage distribution along the winding length for the first fraction of a microsecond is determined by capacitance, which

implies an electric field. To a first approximation, as there are no charges except the impulse wave, the distribution in the transformer is Laplacian for part of a microsecond. This initial distribution can be studied in an electrolytic tank, and Fig. 3 shows an analogue model.

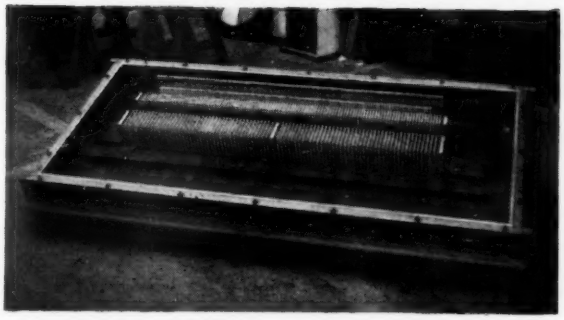


2 *Representation in a tank of a three-dimensional field with circular symmetry in a homogeneous dielectric*
a Original system b Analogue

The potential at any point in the analogue model can be picked up on the surface of the electrolyte by a probe and measured by a bridge circuit. The bridge circuit to measure the potential of the probe is shown in Fig. 4. A capacitor suitable for insertion across either arm of the potentiometer has been found necessary to balance the bridge.

Servo-operated bridge

The operation of the analogue model justifies the use of some form of servo-balancing. One method, automatic plotting, is unsuitable for complex models because of the rows of pins which would impede an equipotential-seeking probe. An automatic balancing bridge determines potentials rapidly and achieves higher accuracy and reliability.

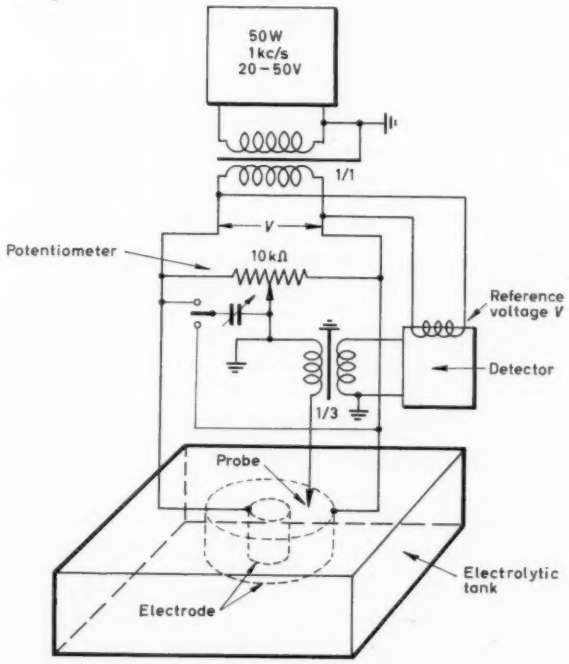


3 *Analogue model of a transformer*

In Fig. 5 the vector diagram shows the process of balancing, where AQ and QD are the potentials of the point Q. V_e is the error signal, and as the potential divider and capacitor are adjusted Q approaches P—which is the balance condition.

The two distinct operations are: (a) adjusting the potentiometer and (b) adjusting the capacitor. Both account for reduction in V_e. However, if V_e can be divided into two components, V_{ep} in phase with V (the applied voltage) and V_{eq} in quadrature with it, the bridge can be balanced by adjusting the potentiometer alone, in which conditions $V_{ep} = 0$.

A suitable phase-sensitive detector employs a half-wave rectifier circuit, and if the capacitors are large enough to charge to the peak voltage, the output from the detector is a direct voltage $= \sqrt{2}\, V_{ep}$. In practice the output approximates to V_{ep}.



4 *Circuit for measuring potentials in an electrolytic tank*

Servo system

A closed-loop servo system built around the phase-sensitive detector takes into account the magnitude and direction of the error signal and operates a corrective action to reduce it to almost zero.

The performances required from the servo are:
An accuracy in reading potentials within 0·1% of the applied voltage
An adequate stability
As simple an arrangement as possible.

The elements of the closed-loop servo system are:
The potential divider
Phase-sensitive detector
Split-field d.c. motor
D.C. amplifier: the field windings of the motor form the anode load of the output stage
Tachogenerator: this is built on the same shaft as the motor and is used to give velocity feedback to the system
Gearbox.

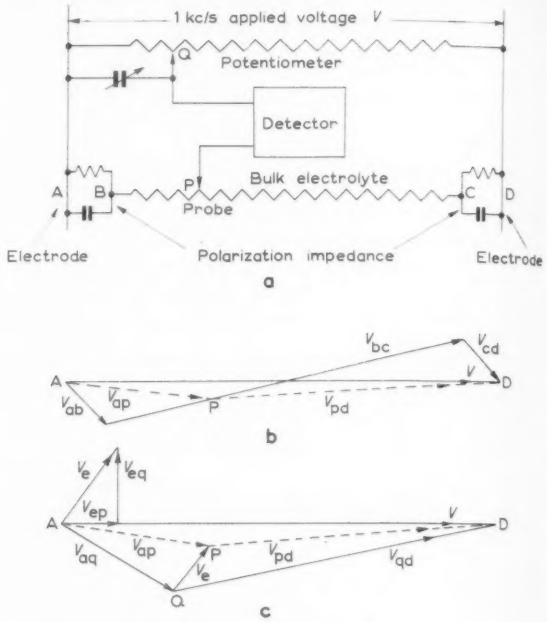
Servo design

The servo can be analysed by determining the open-loop transfer function of individual elements. The open-loop transfer function of the system is $K_1G_1(S) \cdot K_2G_2(S) \cdot K_3G_3(S)$ if $K_1G_1(S)$, $K_2G_2(S)$ are the transfer functions of individual elements to make up the chain. A log-modulus plot or a phase-amplitude plot on the Argand diagram is sufficient to study stability conditions.

In practice enough gain is provided to make the system oscillate, and velocity feedback is then used to stabilize it. Other forms of feedback could be used for the same purpose.

Acknowledgments

I wish to thank my colleagues for their help, in particular Mr. W. A. Sharpley for the initial suggestion of an automatic bridge and for discussion of the theory of the phase-sensitive detector and Mr. B. English for suggestions as to how the bridge might be made. I am indebted to Prof. M. G. Say and



5 *Balancing an a.c. bridge*
- **a** Equivalent circuit of the electrolyte ABPCD and other elements AQ, AD of the bridge
- **b** Vector diagram of electrolyte
- **c** Vector diagram of bridge showing error voltage V_e

Mr. E. O. Taylor for their encouragement and to Mr. D. McDonald for permission to use material from his paper.

Finally, I wish to thank the directors of Bruce Peebles and Co. Ltd. for permission to read the paper.

621.317.329

Synopses of papers

THE following are synopses of papers published in the *Proceedings* which have not been read at Institution meetings and which have not been reviewed in the *Journal*. They are included here primarily for reference. The papers, except for that by D. W. Fry, have not been published individually, as have those for reading at meetings, but reprints will be available shortly

Nuclear energy from controlled thermonuclear reaction

A synopsis of a lecture (paper 2903) entitled 'A review of work towards nuclear energy from controlled thermonuclear reaction' by D. W. Fry, M.Sc., Member, delivered at the Ordinary Meeting in conjunction with the British Nuclear Energy Conference on the 4th December 1958. It was published individually in Aprtl 1959 and is republished this month in Part A of the Proceedings. The author is at the U.K.A.E.A. Atomic Energy Research Establishment.

THE main approaches being followed in the search for thermonuclear power are outlined. The experimental results obtained indicate that the behaviour of fully ionized plasmas is extremely complex.

After discussing the fundamental ideas and problems the author describes some of the devices mentioned at the second United Nations conference on the Peaceful uses of atomic energy held in Geneva during September 1958. He classifies them as closed-line containment systems, including pinched-discharge installations, the Stellarator and the Astron; open-line containment methods; and miscellaneous.

In general terms the engineering problems are: the economic storage of energy in the tens to hundreds of megajoules region; its switching into and out of circuit, in some cases in very short times and with reactive loads; the design of a magnetic-field system to withstand the forces associated with establishing the high fields required; and circuit protection.

621.039 : 621.387

Arcs in transverse magnetic field at atmospheric pressure

A synopsis of a Supply Section paper (3044) entitled 'Arc movement in a transverse magnetic field at atmospheric pressure' by P. E. Secker, B.Sc.(Eng.), Graduate, and A. E. Guile, Ph.D., B.Sc.(Eng.), Associate Member. The paper is published this month in Part A of the Proceedings. Mr. Secker is, and Dr. Guile was formerly, in the Department of Electrical Engineering, Queen Mary College, University of London. Dr. Guile is now in the Department of Electrical Engineering, University of Rangoon, Burma.

THE velocities of d.c. arcs moving in the forward direction in a transverse magnetic field in air at atmospheric pressure were measured at arc currents up to 700amp and magnetic fields up to 0·1 Wb/m^2.

The over-all arc movement is at all times controlled and repeatable within surprisingly small limits, any scatter being due mainly to differences in cathode surface layers.

Above about 40amp the velocity of the cathode root and thus that of the whole arc is independent of arc current whether its movement is continuous or not. 621.387

Starting of single-phase induction motors

A synopsis of a Utilization Section paper (3049) entitled 'The starting of single-phase induction motors having asymmetrical stator windings in quadrature' by C. S. Jha, B.Sc., and A. R. Daniels, M.Sc., Graduates. The paper is published this month in Part A of the Proceedings. Mr. Jha is, and Mr. Daniels was formerly, in the Electrical Engineering Department, University of Bristol. Mr. Daniels is now at the College of Technology, Bristol.

THE operation of an asymmetrical 2-phase induction motor on a single-phase supply system is analysed by the method of symmetrical components, and performance equations for the special problem of starting the machine are expressed in terms of three dimensionless parameters.

The effects of varying these parameters are studied in detail, and conditions for optimum starting performance are established. Starting characteristics are given for a wide range of the parameters, but the best performance is obtained with a capacitive convertor selected to give minimum unbalance. Properly interpreted the results are applicable to standard single-phase induction motors of any rating. 621.313.33

Frozen-mercury technique for casting waveguide parts

A synopsis of an Electronics and Communications Section paper (2996) entitled 'Manufacture of waveguide parts by investment casting from frozen-mercury patterns' by H. H. Scholefield, Ph.D., B.Met., H. H. H. Green, B.Sc.(Eng.), Associate Member, and R. E. Gossett. The paper was published in the July 1959 Proceedings, Part B. The authors are with Sankey-Telcon Ltd.

THE authors explain and discuss the capabilities and limitations of the recently developed frozen-mercury process for the production of cast parts.

Cast complex horns containing transfer sections have proved particularly valuable as they are difficult to produce by fabrication techniques. The waveguide parts are cast in aluminium alloy, gun-metal or other alloy according to requirements.

Consistency of dimension in relation to design tolerances is examined. Typical examples are described and tolerances and surface finish obtainable discussed. 621.372.8 : 621.744

Analogue computer for costing power changes

A synopsis of a Supply Section paper (2890) entitled 'An analogue computer to evaluate the cost of changes in power on a power system' by K. W. Wardrop, B.Sc.(Eng.), Associate Member. The paper is published this month in Part A of the Proceedings. The author is in the Electrical Engineering Department, Imperial College of Science and Technology, London.

CHANGES in the cost of supplying power due to changes in total power demand or in the allocation of power between generating stations are evaluated by an analogue computer.

Changes in the power lost in transmission are included in the evaluation, and systematic changes in power conditions are made automatically to discover the minimum cost of supplying power. 621.317.79 : 621.311.161.017 : 338.58

Reactance of surface supporting surface waves

A synopsis of an Electronics and Communications Section paper (2881) entitled 'The estimation of the reactance of a loss-free surface supporting surface waves' by K. P. Sharma, Ph.D., Graduate. The paper was published in the July 1959 Proceedings, Part B. The author was formerly in the Department of Electrical Engineering, University College London, and is now in the Department of Physics, L.S. College, Bihar University, Muzaffarpur, India.

THE transmission-line analogue technique is applied to calculate the reactances of a few types of surface which may support surface waves. Experimental methods of estimating the reactances of such surfaces are discussed with special reference to the difficulties encountered in practice.

Results obtained by theoretical calculations are found to agree with experimental results within the limits of experimental error and the validity of the assumptions made in the theoretical calculations. 621.372 : 621.317.332.2

CORRESPONDENCE

LOAD FACTOR

THE Foreword of the April 1959 *Journal* (p. 203) comments sadly on the impossibility of storing electricity. Is not this theme somewhat of an anachronism, based as it seems to be on the outmoded idea that an alternator or generator 'makes' electricity? Surely the modern conception is that electricity is present all the time at rest in the armatures of the machinery, the cables and the apparatus to which they are connected and is set in motion by the rotation of the machines. Is it not then in this sense actually in storage and cannot each machine therefore be regarded as a reservoir whose capacity is only limited by the rate at which the electricity can be moved or taken out of it?

For instance the fact that a machine producing a current of 3000 amperes delivers 3000 coulombs of electricity per second presupposes (since the machine does not make it) that this electricity must have been stored *somewhere*, and to say in spite of this that electricity cannot be stored is not being very realistic.

The installation of sufficient plant to deal with the maximum load is therefore storage of electricity in actual fact, and as presumably the machines not in use do not consume anything and do not wear out the question of load factor is one of idle capital. So what? To hear this very large bee buzzing in the bonnet of the electrical-supply hierarchy one would think nobody else ever had any idle plant, the fact being of course that every business activity suffers from it.

Have electrical engineers never seen bus garages full of idle buses at night-time and during part of the day; railway sidings full of empty trains; huge reservoirs full of water; gasholders full of gas; shops and office buildings shut for two-thirds of the 24 hours; seaside hotels empty nearly half the year; and 10000-line telephone exchanges with hardly a selector in use; not to mention such things as ships, aircraft, and television transmitters all with utilization curves of vertiginous irregularity?

The poor load factor is dealt with by these institutions in varying ways. Retailers know that any suggestion of varying prices with the time of buying is definitely 'out' simply because the customer would not stand for it. The Post Office completely illogically has to all intents and purposes a flat rate for inland mails and a charge per telephone call which varies with time, distance and (because of the rental of the line) the number of calls. Water companies and gas authorities seem to have a sliding scale of charges favouring the big user. The electrical-supply people have a range of tariffs which favour the big industries, the domestic user and the farmer at the expense of the commercial user, especially the smaller ones (i.e. those with a supposedly bad load factor).

These varying charges have a common fallacy: and that is the assumption that a consumer has any control over the nature of his load, when in fact it is dictated by the requirements of his activities. A shopkeeper for instance cannot shift his lighting load to midday. These various ways of trying to make a consumer contribute towards the interest on the idle capital it is alleged his particular load factor demands are therefore penalizing him for conditions which are beyond his power to alter. To the consumer who suffers this imposition by paying often more than twice the average price per kilowatt-hour 'load factor' is just a dirty term.

Is it not high time that the electricity-supply authorities abandoned these unethical tariffs, forgot their obsession with the load factor and adopted the much fairer, more straightforward uniform flat rate for all consumers?

O. D. ROBINSON, MEMBER
90 West Cliff Road
Bournemouth, Hampshire

2nd June 1959

THE HEAVISIDE PAPERS FOUND AT PAIGNTON IN 1957

I HAVE read the monograph by Mr. H. J. Josephs* with much interest since it shows the historical background of modern electromagnetic theory. It is important to realize that as far back as the years 1884–87 Oliver Heaviside published the present vector formulation of Maxwell's (quaternion) equations (1873) which were based on the quaternion theory developed by Hamilton (1866). To anyone who reads Maxwell's 'Treatise' the tremendous advantage of the vector notation becomes quite evident.

Another important fact that emerges from this monograph is that Heaviside was the first to introduce the magnetic currents (and charges). These magnetic currents and charges play a very important role in present electromagnetic theory, especially with respect to vector boundary-value problems where the surface magnetic current densities actually exist physically.

Therefore I suggest that the following well known symmetric electromagnetic equations:

$$\nabla \times \boldsymbol{H} = \boldsymbol{J} + \frac{\partial \boldsymbol{D}}{\partial t} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$\nabla \times \boldsymbol{E} = -\boldsymbol{J}_m - \frac{\partial \boldsymbol{B}}{\partial t} \quad . \quad . \quad . \quad . \quad (2)$$

$$\nabla \cdot \boldsymbol{D} = \rho \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

$$\nabla \cdot \boldsymbol{B} = \rho_m \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

be designated the 'Maxwell–Heaviside equations'. The major contributions of Heaviside mentioned above make the inclusion of his name imperative.

I also suggest that the electromagnetic-energy relationship be renamed the 'Poynting–Heaviside theorem' since the derivation of this theorem is always given today by the simpler method of Heaviside. It would also emphasize the fact that $\boldsymbol{P} = \boldsymbol{E} \times \boldsymbol{H} + \boldsymbol{G}$ where $\boldsymbol{G} = \nabla \times \boldsymbol{L}$, a fact which is

* JOSEPHS, H. J.: 'The Heaviside papers found at Paignton in 1957', *Proceedings I.E.E.*, Monograph No. 319, January 1959 (106 C, p. 70)

often overlooked. The introduction of the name Heaviside would pay tribute to the person who contributed so much to electromagnetic theory and helped to create it in the form which we use extensively today.

In addition I would like to make certain historical notes. The first text on the elements of vector analysis of which I have any knowledge was published by Prof. J. W. Gibbs at Yale University during the years 1881–84 by the company Tuttle, Morhouse and Taylor.

Evidence that this was a major contribution at the time and that Prof. Gibbs played a leading role in the bringing in of modern vector-analysis notation we find in a passage from the introduction to a book by Prof. P. G. Tait, 'Quaternions', published by Cambridge University Press (1873; 1890): 'Even Prof. J. W. Gibbs must be ranked as one of the retarders of quaternion progress, in virtue of his pamphlet on vector analysis, a sort of hermaphrodite monster compounded of the notations of Hamilton and Grassman.'

The classical text on vector analysis was written by J. W. Gibbs and E. B. Wilson and was published in New York by Scribner in 1901. I think that the modern vector analysis should be definitely associated with the name of Gibbs.

It is interesting to note that as late as 1922 Prof. J. B. Shaw in his book 'Vector calculus' (Van Nostrand, 1922) wrote in the introduction: 'The author has examined the various methods that go under the name of vectors and finds that for purposes of the physicist and for most of those of the geometer the use of quaternions is far the simplest in theory and practice.' As far as I know this is the last authoritative opinion on the preference of quaternion notation to that of the now universally accepted vector analysis. However without Hamilton's quaternion theory the vector analysis of Gibbs would not have come into existence at such an early date, and the progress of physics in general and of electromagnetic theory in particular would have been much slower.

H. UNZ, Assistant Professor, Electrical Engineering
Electrical Engineering Department
School of Engineering and Architecture
University of Kansas
18th May 1959 Lawrence, Kansas, U.S.A.

WHAT IS NEGATIVE IMPEDANCE?

I FEEL obliged to comment on Mr. M. O. Williams's letter which appeared in the March *Journal*, p. 169.

Mr. Williams's consternation is not unnatural. Indeed, almost every sophomore student when first presented with the concept of negative impedance supported by physical evidence of its manifestation reacts as did Mr. Williams.

I quote from Mr. Williams's letter that:

'The British Standards Institution, supported, I believe, by The Institution, has pronounced that impedance is the ratio of the r.m.s. electromotive force in the circuit to the r.m.s. current which is produced thereby, and that it should be denoted by the symbol Z.'

This definition of impedance is of course incomplete and therefore patently incorrect. That Mr. Williams should base his ensuing discussion on this misleading statement is sufficient reason alone to consider his conclusions suspect.

Since a negative impedance $-\boldsymbol{Z}$ may be written in complex exponential form as:

$$-\boldsymbol{Z} = Z\varepsilon^{j\pi}$$

Mr. Williams contends that the right-hand expression is just another impedance and that attachment of the adjective 'negative' is therefore 'an entirely unnecessary and irrelevant complication . . . pedagogically unsound . . . a considerable distortion of ordinarily accepted concepts.'

These literary and unscientific proclamations were presumably motivated by Mr. Williams's discovery of the well known and elementary fact that the set of all real numbers is indeed a subset of the set of all complex numbers. Specifically he notes that '. . . the operator -1 can be used as an abbreviation for a phase shift of 180°.'

While I would have preferred him to make a more general statement than just this and hence accord the situation the mathematical rigour which it deserves I am more concerned with the fact that he doesn't care to equally well identify positive real numbers as complex numbers—for example the number $+1$.

We may restrict ourselves to steady-state analysis and to cisoidal time-functions, as by implication did Mr. Williams. The impedance of a two-terminal circuit is then by definition equal to the constant of proportionality which relates the cisoidal voltage drop across the two terminals to the cisoidal current which flows through the circuit from the terminal of assumed higher potential.

The definition is purely mathematical and has nothing whatever to do with the voltage and current directions and polarities which might be measured in a physical circuit. Furthermore it is not necessary to specify that the voltages and currents be r.m.s. quantities.

If the constant of proportionality turns out to be a positive real number we choose to call it a resistance. If it turns out to be a negative real number then it is unequivocally a negative resistance. From the literary viewpoint we could invoke the subtleties of the English language and call a negative resistance by some other name—for example 'assistance'. From the scientific viewpoint however such terminology is aesthetically undesirable.

Similar remarks apply to the concepts of general immittances and negative immittances.

I note incidentally that Mr. Williams fails to make any differentiation between the statement:

$$-\boldsymbol{Z} = Z\varepsilon^{j\pi}$$

and the statement:

$$-\boldsymbol{Z} = Z\varepsilon^{-j\pi}$$

yet I cannot believe that he assumes these to be one and the same statement!

In conclusion I find it unfortunate that Mr. Williams should have condemned the term 'negative impedance' as slang. The only time that I have seen the term 'negative impedance' misused is in connection with impedances whose real parts

were negative. The latter are negative impedances only when their imaginary parts are negative reactances.

B. R. MYERS, PH.D., ASSOCIATE MEMBER
Assistant Professor, Circuit Theory Group
Dept. of Electrical Engineering, University of Illinois
Urbana, Illinois, U.S.A.

9th June 1959

ELECTRONICS AND ELECTRICAL ENGINEERING

THE current discussion on the relation between electronics and electrical engineering shows some confusion of concepts and consequent conflicts of opinion.

The term 'electronics' has been defined by the International Electrotechnical Commission in their International electrotechnical vocabulary, 2nd edition, Group 07—Electronics, published in 1956, as follows:

Electronics (noun): That branch of science and technology which deals with the study of the phenomena of conduction of electricity in a vacuum, in a gas, and in semiconductors, and with the utilization of devices based on these phenomena. Electronic (adjective): Qualifies that which is concerned with electronics, or any device which functions according to its principles.

Hence, based on these definitions, electronic devices may be classified according to the principles of their design:

1. Electronic devices with electron-emissive cathode
   - 1.1. Hot-cathode valves and tubes
   - 1.1.1. Vacuum types
   - 1.1.2. Gas-filled types
   - 1.2. Cold-cathode valves and tubes
   - 1.3. Mercury-cathode valves
   - 1.4. Photocathode valves and tubes
   - 1.4.1. Vacuum types
   - 1.4.2. Gas-filled types
2. Semiconductor devices
   - 2.1. Selenium-type devices
   - 2.2. Copper-oxide-type devices
   - 2.3. Germanium- and silicon-type devices

Electronic devices are used either (a) in 'electronic circuits' to give effects such as switching in a power rectifier or intermodulation in a radio or (b) to provide an electronic effect, e.g. the generation of light in a gas conduction device, the production of X-radiation in an X-ray tube, or the conversion of light to a corresponding current in a photocell.

The first practical electronic devices were arc lamps. The carbon-arc lamp was patented by Wright in England in 1845 and later employed for street lighting in Baltimore in the late '70s, and open carbon-arc lamps were constructed by Charles F. Brush in 1876. A mercury-vapour arc lamp was first demonstrated by John Thomas Way in London in 1860. Such lamps were commercially produced by Peter Cooper Hewitt who showed them in 1901 at the opening of the new building of the Columbia University in New York. Hewitt also turned his attention to the rectification of alternating current with mercury-vapour valves, thus making use of the discovery in 1882 by M. M. Jamin in France that the mercury-pool arc has a unidirectional effect.

The invention of the hot-cathode vacuum diode by John Ambrose Fleming in 1904 marked the beginning of the utilization of hot-cathode electronic vacuum devices for radio purposes.

Practical application of semiconductor devices may be considered to have started in 1876 when E. W. von Siemens constructed the first selenium photocell. Semiconductor devices became significant for power electronic circuits in 1925 when E. Presser in Germany announced the selenium diode which was followed in 1926 by the copper-oxide diode constructed by L. O. Grondahl in the United States. The invention of the transistor in 1948 as the result of the work by J. Bardeen, W. H. Brattain and W. Shockley started the development of a multitude of types of semiconductor device for both light-current and power electronics.

Defining electrical engineering as the practical application of electricity we realize that electronics forms a section of electrical engineering and that the two have grown together from their early beginnings.

R. FEINBERG, DR.ING., M.SC., ASSOCIATE MEMBER
Department of Electrical Engineering
The Manchester College of Science and Technology
Sackville Street
Manchester 1

3rd June 1959

CHEAPER SUBSCRIBER CONNECTION

THE average cost of telephone-exchange apparatus per new subscriber will have fallen by a quarter compared with 1954–55 by next year. Five years ago apparatus costing nearly £35 was required in every new telephone exchange for each subscriber connected to it; this year it costs just under £32 and next year it will cost £27.

This is attributed to technical changes such as the use of line finders, to the provision of switching equipment closely in accordance with traffic requirements (some newly connected subscribers do not make many calls), and to the adding of apparatus only as the number of lines connected to an exchange and the traffic grow. In addition the simplification of the call-charge tariff at the beginning of 1959 eliminated the need for equipment to discriminate between calls of 5, 7½, 12½ and 15 miles' distance.

POPULARITY OF S.T.D.

NINETY per cent. of telephone subscribers in the Bristol Central area replying to a recent Post Office inquiry agreed that subscriber trunk dialling is both quicker and cheaper. The Post Office reports also that since the new system was inaugurated by the Queen on the 5th December 1958 traffic there has increased by 45%.

Charges for local and dialled trunk calls are based on a 2d. unit of time, depending on distance, and 90% of those customers who replied were taking advantage of the new tariff for short calls by restricting some calls to a minute or less. About 30% stated that the new system had led them to make more calls.

OBITUARY

ROBERT ALLAN

Robert Allan, who was killed in an air crash over Italy on the 22nd October 1958, was born on the 11th September 1909. He was educated at Middlesbrough High School and apprenticed to Middlesbrough Corporation Electricity Department, Sunderland Forge and Engineering Co. Ltd., and the General Electric Co. Ltd., Birmingham. He received his engineering education at the technical colleges of Constantine, Sunderland and Birmingham.

He remained with the General Electric Co. on the completion of his apprenticeship for three years before being appointed manager of the contract department of the Madras branch of the General Electric Co. of India Ltd. in 1933. In 1946 he became chief electrical and mechanical engineer of the branch and in 1951 spent six months as a special representative in Uganda. He was transferred to Iraq in 1957 as a representative of the G.E.C.

He flew to London on the 17th October prior to taking up an appointment with the company in Ghana and was on leave, flying to Italy with his fiancée, when he was killed in the ill-fated aircraft which collided with an Italian jet fighter.

He was unable to join the forces in the Second World War for medical reasons but was actively engaged on urgent ship repairs and defence contracts. He was a most versatile and practical electrical engineer, with great charm of manner. He acted as welfare officer in the Madras branch of the G.E.C. of India, and it is no exaggeration to say that the workmen and staff loved him.

He served on the committees of the Caledonian Society in Madras and the Madras Gymkhana Club. He was a good swimmer, spending many hours teaching children of the latter club to swim and dive, and a keen and very successful photographer.

He joined The Institution as an Associate Member in 1947 and was elected a Member in 1953. He served on the Madras Local Committee from 1949 to 1958. He was one of the first members of the Illuminating Engineering Society of India. F. W.-C.

LUIGI EMANUELI

Luigi Emanueli, who died on the 17th February 1959, was born in Milan on the 4th May 1883. At the age of 23 he obtained a degree in electrotechnical industrial engineering at the Milan Polytechnic.

In 1907 he joined Pirelli Società per Azioni, Milan, and concentrated on electrical research, particularly the study of dielectric losses under alternating voltage which led him in 1911 to be the first to recognize the phenomenon of the ionization of gas in voids in dielectrics under these conditions. He studied the properties of impregnating compounds and papers used in cable manufacture and discovered in 1918 the relationship between the porosity and electric strength of paper. This work led directly to the development of the oil-filled cable with which his name will always be associated.

The first experimental 132kV cable was installed at Brugherio near Milan in 1924, followed in 1927 by installations at the same voltage in New York and Chicago. The first oil-filled cable in Great Britain was laid in 1929. In 1932 an experimental 220kV oil-filled cable was laid at Cislago near Milan, followed by the Paris 220kV oil-filled cable installation in 1936. These developments had all been based on the fundamental research work carried out by Emanueli or under his direction, and it can be fairly said that he was generally recognized to be the leading cable engineer of his day and generation in this field.

In 1927 he read a paper on the technique of oil-filled cables before a regional meeting of the American Institute of Electrical Engineers for which he was awarded a special prize and nomination as a life member of the Institute. In 1958 he was elected an honorary member of the Institute. In 1929 he was invited by the Faculty of Engineering of the University of London to deliver a course of lectures on cables, entitled 'High-voltage cables'. This was followed by a visit to Japan.

Emanueli was also responsible for much original research in the field of telecommunication. In 1910 he designed and installed a continuously loaded telephone cable between Milan and the hydro-electric station at Grossoto, a distance of 160 miles, which was at that time the longest telephone cable in the world, and in 1913 he designed the submarine telephone cable between Italy and Sardinia. Much later he designed and supervised the installation of a submarine telegraph cable which was laid in 1953 between Spain and Brazil.

In 1917 he became chief engineer of the cable department of Pirelli, being appointed central manager in 1938. During these years he was closely associated with the technical direction of Pirelli-General Cable Works Ltd., of which he became a director in 1939.

In 1944 he became responsible for the rubber division of Pirelli and in the same year was appointed general manager. At the time of his death he was vice-president of Pirelli, Milan.

Emanueli was a man of rare charm and modesty of manner whose personal qualities, quite apart from his eminence in his chosen field, resulted in the formation of lasting personal friendships throughout the world and not least in this country. His inquiring mind found an outlet in wide fields of culture, and the range of his interest in the whole field of the humanities made him a fascinating companion. He is survived by his widow and a daughter.

He joined The Institution as a Member in 1922. Just before his death he was awarded the Faraday Medal, but he did not live to receive it personally at the hands of the President. He was president of the Associazione Elettrotecnica Italiana from 1933 to 1935. J. R. H.

ARTHUR EDWARD H. DINHAM-PEREN

Arthur Edward H. Dinham-Peren, who died in tragic circumstances as the result of a fire on the 9th February 1959, was born at South Petherton, Somerset, on the 12th June 1882. Going to Australia at an early age, he matriculated at Melbourne University in 1901 and received his early technical training at Melbourne Technical College. In 1905 he became a 'college' electrical apprentice with the British Westinghouse Co. and worked for them as an engineer from 1908.

In 1910 he went to South Africa, serving with De Beer's Consolidated Mines Ltd. as assistant electrical engineer. Prior to the outbreak of the 1914–1918 War he was commissioned in the Forces and served throughout the German South-West Africa campaign; during the last two and a half years of the war he was with the British Expeditionary Force in France, being demobilized as a captain in the Royal Engineers in 1920.

After working for three years with Metropolitan-Vickers Electrical Co. he joined Whitehall Securities Corporation Ltd. in 1923 and remained with them until his retirement in 1953. While with this organization he was in the early years engaged in a consultative capacity for the operation of electricity supply undertakings in Chile and Mexico and from 1930 until nationalization was responsible for the design and construction of the transmission and distribution systems of the group of electricity companies controlled by West of England Electric Investments Ltd.

He was extremely thorough in all he did and an enthusiast for compliance with safety regulations. He was fond of walking and while interested in most field sports was particularly keen on cricket and tennis and wanted no better relaxation than a day at Lord's. Institution matters were always of great interest to him, and he was a most regular attender at meetings, even after his retirement. He is survived by his two sons and a daughter.

He joined The Institution as a Student in 1908 and was elected an Associate Member in 1909 and a Member in 1920. F. G. W.

HAROLD GORDON FRASER

Col. Harold Gordon Fraser, M.C., T.D., D.L., M.A., who died on the 12th February 1959, was born in the West Riding of Yorkshire on the 28th January 1886. He was educated at Sevenoaks School and was apprenticed to Stockport Corporation Electricity Undertaking, studying part-time at Manchester School of Technology. He then held positions with Leigh, Blackburn and Wakefield undertakings. His service with the latter was broken by the 1914–18 War after which he returned to be appointed chief electrical engineer and manager in 1920.

In 1932 the Oxford Corporation exercised its option to take over the undertaking of the Oxford Electric Co.; and 'the Colonel', as he came to be universally known, was chosen to organize the new undertaking. The phenomenal record of the undertaking more than justified this choice. The standard of service to the consumer

insisted upon by him was extremely high, and his exceptional and quick grasp of essentials led to economy and simplification of administration.

When the supply industry was nationalized in 1948 he was selected to undertake the difficult task of welding seven municipal undertakings and four company areas, in addition to nine district units of the Wessex Electricity Co., into the No. 2 (Newbury) Sub-Area of the Southern Electricity Board. It was largely because of the confidence, respect and loyalty he inspired in the whole staff that this operation was so successfully conducted. He served as a member of the Central Electricity Board Consultative Committee for South-West England and South Wales.

He was throughout his life keenly interested in the Territorial Army and was commissioned in the 4th Battalion of the King's Own Yorkshire Light Infantry with whom he went to France in 1915. He was awarded the Military Cross during the Battle of the Somme. After the 1914–18 War he continued to serve in the Territorial Army and commanded, as a lieutenant-colonel, his old battalion and subsequently was appointed honorary colonel. He served with the Home Guard in the Second World War and until recently was a member of the County of Oxford Territorial and Auxiliary Forces Association, serving on the Oxford A.T.C. Committee.

Although he shunned the limelight his services to Oxford University and the city were recognized by his being awarded an honorary degree of M.A., and during his retirement he was made a deputy-lieutenant of the County of Oxford.

He will long be remembered by those who were privileged to work closely with him for his keen if sometimes caustic sense of humour and his terseness of expression but most of all for his kindliness and care for the well-being of all those under him, many of whom could testify to his concern and generosity. He was a keen sportsman and played cricket for the Yorkshire Gentlemen and for Rochdale. He was also a great home-lover and an enthusiastic gardener and rose grower. He is survived by his widow and a married daughter.

He joined The Institution as an Associate Member in 1920 and was elected a Member in 1930. He served on the North Midland Centre Committee from 1921 to 1931, being vice-chairman from 1928 to 1930 and chairman in 1930–31. He helped to found the Oxford District of The Institution. J. L. T.

JOHN HEDLEY

John Hedley, I.S.O., who died on the 23rd February 1959 at the age of 84, entered Post Office service in Manchester in 1889 and remained there for ten years. He then joined the engineering department and after a short period in Nottingham was transferred to London where he served until he retired in 1934. Throughout this period he was engaged on telephone-exchange work, especially design, development and installation. He was thus associated with the development of automatic telephony in the Post Office from its beginning in 1912. When he became head of the telephone branch of the engineer-in-chief's office in 1929 the automatic system was widespread over the country as a whole and had made good progress in London.

Hedley had all the forthrightness and energy of his native Lancashire but combined with it a friendly and helpful disposition and a keen sense of humour. He is particularly remembered for his uncanny flair for circuit design.

He was a man of wide interests, but his principal hobbies were chess and bowls. Although a shrewd chess-player his outstanding love was for bowls in which game he had many successes and was at one time champion of Essex. He was a widower and is survived by his three sons.

He joined The Institution as an Associate Member in 1920 and was elected a Member in 1922. G. F. O.

ARTHUR STEPHENS HERBERT

Arthur Stephens Herbert, who died on the 10th March 1959 at his home at Northwood, was born in London on the 18th September 1881. He was educated at Merchant Taylors' School and Finsbury Technical College.

After joining the firm of Whitting Eborall and spending a short time at Charleroi in Belgium he moved to Kolben and Co., Prague, and was responsible for the installation of the hydro-electric plant in the Duck Reach power station of the Launceston (Tasmania) City Council in 1906.

Shortly after returning to Europe at the conclusion of this contract he spent two years with Siemens-Schuckert in Berlin and was then appointed general manager for Siemens Brothers Dynamo Works Ltd. in Canada, transferring in 1913 to a similar position in Australia. He spent a short period in London from 1920 to 1922 and went back to Australia as general manager for the English Electric Co. Ltd.

Returning to England in 1931 he was appointed deputy export manager of the company. In 1933 he joined as managing director Herbert and Son Ltd., Smithfield, with whom he had family ties.

During his stay in Australia he was closely associated with the formation of the Institution of Engineers (Australia) and on his return to England served for some time on the Oversea Activities Committee of The Institution.

Herbert was a very friendly person, open-hearted and generous; he had a quick sense of humour and an infectious laugh. A great reader, his special study was the period of the French Revolution concerning which he built up a remarkable collection of books. He was deservedly happy in his married life and is survived by two sons, of whom he was very proud.

He joined The Institution as a Student in 1899 and was elected an Associate Member in 1906 and a Member in 1912. A. E. S.

ROBERT PICKERSGILL HOWGRAVE-GRAHAM

Robert Pickersgill Howgrave-Graham, who died on the 25th March 1959, was born at Hampstead on the 9th July 1880.

He studied electrical engineering at Finsbury Technical College under Silvanus Thompson and subsequently pursued his career there for some 20 years. He was appointed a demonstrator on the completion of his course, assisted Silvanus Thompson in his researches and undertook some teaching. Just prior to the First World War he was associated with Lodge and Muirhead in the development of the wheel coherer. During the war, unfit for active service, he continued his teaching and research at Finsbury.

Shortly after the war he became engaged in the important patent action brought by the De Forest Radio Telegraph and Telephone Co. of New York on the application of Fleming and the Marconi Co. for an extension of Fleming's main thermionic diode patent. He gave evidence in support of the case of the De Forest Co.

In 1919 he was appointed to a lectureship at the Northampton Polytechnic and continued teaching there until his retirement in 1945. Throughout the Second World War he carried on his teaching to civilian and Service students with only one interruption, in 1944, when he was buried in the debris of his house which was demolished by a flying bomb. He was an inspiring teacher and gave sympathetic understanding and unstinted help to anyone in real difficulty.

Distinguished as he was as a teacher of electrical engineering he was better known for his work in the field of archaeology. Pursuing this subject as a hobby from about 16 years of age he became a specialist and an authority on medieval church clocks. He did most notable work in connection with the restoration of the Wells clock which is now in the Science Museum and the Salisbury Cathedral clock which was reinstated in the cathedral in 1956.

He was a skilled photographer and applied it to the architecture of medieval churches. Many of his strikingly beautiful photographs were reproduced in works on Gothic art. On his retirement he was appointed an assistant keeper of the muniments at Westminster Abbey. His skilful and scholarly work on the restoration of the earlier royal effigies is well known.

A quiet, kindly and sensitive man, he possessed courage and perseverance and the spirit of inquiry. His sense of humour, his feeling for the quaint and incongruous endeared him to those who knew him well. He married in 1944 and is survived by his widow.

He joined The Institution as a Student in 1898 and was elected an Associate in 1902, an Associate Member in 1906 and a Member in 1912. He was awarded the Salomons Scholarship in 1900, the Second Student Premium jointly with M. R. Gardner for their paper entitled 'The synchronizing of alternators' in 1900, and the First Student Premium for his paper entitled 'Hertz waves and wireless telegraphy' in 1901. J. G.

IAN WARD ANDERSON KIRKWOOD

Ian Ward Anderson Kirkwood, who was born on the 10th May 1903, died on the 19th January 1959. He was educated at Glasgow Academy, Emanuel School, London, and St. Paul's School, W. Kensington, and received his technical training at Faraday House.

In 1925 he joined the technical and research department of A. Reyrolle and Co. Ltd., Hebburn. His work was concerned mainly with insulation problems, and he was recognized throughout the country as one of the leading authorities on insulation and

plastics in general, and in particular as applied to switchgear. He brought remarkable energy and enthusiasm to his work. It was at A. Reyrolle that he met his wife.

In his younger days he was a keen athlete and played rugger and tennis. He was also fond of motoring; and to anyone who did not know his sense of fun a ride in his little sports car could be quite an exciting experience.

Unfortunately he suffered from ill-health during the recent war, and this led to a stroke in 1947 which forced him to retire from the company in 1948. He never recovered from the stroke and led the life of an invalid until his death. He is survived by his widow and a son.

He joined The Institution as a Graduate in 1928 and was elected an Associate Member in 1933 and a Member in 1940. He served on the North-Eastern Centre Committee from 1946 to 1948. He was a founder-member of the north-eastern section of the Plastics Institute and was chairman in 1946–47. H. L.

WILLIAM McFARLANE

William McFarlane, O.B.E., B.SC., who was born at Blantyre on the 2nd April 1886, died at Parkhead, Glasgow, on the 13th March 1959. His education, obtained at Carluke H.G. School, Lanarkshire, was of a Spartan type, as was his apprenticeship in mechanical engineering, served under a versatile and talented master who considered work to be the only real welfare.

After three years as a journeyman turner and fitter with Anderson Boyes and Co. Ltd., Motherwell, he took a course in engineering science at Glasgow University. On graduating B.Sc. with distinction in 1912 he worked as a shift engineer in the substations and power station of Glasgow Corporation tramways department before joining Brown Boveri (British) Ltd. as a supervising engineer. He had to work in a wide variety of industries—erecting, balancing, commissioning and testing turbo-alternators and centrifugal blowers—helped only by unskilled labour recruited locally by himself.

He was a pioneer in sudden short-circuit testing of alternators and showed much ingenuity in rebuilding damaged plant. War work followed as chief electrical engineer in the National Projectile Factory, and a year later in 1916 he was appointed chief electrical engineer with William Beardmore and Co. Ltd., Mossend steel works, where he remained for 12 years, rising to the position of chief engineer.

In 1928 he was appointed operation engineer to the Central and South Scotland area of the Central Electricity Board, and he continued to work, as chief generation engineer (operation), under the British Electricity Authority.

The home life and conduct of McFarlane were exemplary, and his good works are continued by his widow and family. He was kind and generous and did much to help the E.I.B.A. His love of the Highlands of Scotland made Wester Ross, the Mecca of his holiday pilgrimages, his chief delight.

He joined The Institution as an Associate Member in 1929 and was elected a Member in 1949. He was appointed an Officer of the Order of the British Empire in 1952. C. W. M.

JOHN TURNER MacGREGOR-MORRIS

Prof. John Turner MacGregor-Morris, D.SC., who died on the 18th March 1959, was born on the 27th October 1872. He received his electrical engineering education at University College London and was for a time personal assistant there to Sir Ambrose Fleming. He established the electrical engineering department at East London College (now Queen Mary College) in 1898 and was professor of electrical engineering there from 1903 to 1938. In 1939 he became honorary research associate of the electrical engineering department of University College London.

His great interest was in research work, and although during the period of his professorship financial support for research was extremely meagre he managed to institute and maintain a considerable amount of investigation in his department. During the First World War he developed a successful hydrophone for submarine detection.

His lectures were unorthodox, having little textbook content, but they were stimulating, particularly to the potential research student. His lectures to the first-year students were illustrated by excellent experimental demonstrations, and he gave much time and thought to these.

Two subjects in which he took a special interest were cathode-ray tubes and high-voltage engineering. He did research work on cathode-ray tubes from their infancy and was joint author of one of the first textbooks dealing with them. He fostered the development of the well known high-voltage laboratory at Queen Mary College which was opened in 1936.

He took a great personal interest in his staff and in his students. Each year he and Mrs. MacGregor-Morris invited staff and research students to dinner and a social evening at their Hampstead home. In the course of the evening there was usually a short talk on religion given by some well known engineer.

The Professor played a good game of tennis. Quite late in life he learned to play the 'cello. His last illness was mercifully short, and his Christian faith sustained and comforted him to the end.

He joined The Institution as a Student in 1892 and was elected an Associate in 1894, an Associate Member in 1899 and a Member in 1905. He was a keen supporter of The Institution and was often to be seen at meetings up to a short time before his death. He was awarded the Salomons Scholarship in 1893, was chairman of the Meter and Instrument Section in 1934–35 and gave the Faraday Lecture at the local Centres in 1932–33. He represented The Institution on several international commissions on illumination. He was also a Member of the Institution of Civil Engineers and an original member of the Illuminating Engineering Society, being president in 1940–41. He was a Fellow of University College and Queen Mary College, London. His paper on 'Experiments on the candle-power and brightness of the positive crater of the electric arc, using solid carbons and graphite electrodes' was published in the *Journal* in 1944. W. J. J.

HARRY PAYN

Harry Payn, who was born on the 14th May 1895, died peacefully at his home in Boston on the 24th April 1959 on the threshold of retirement after working 47 years in the electricity supply industry.

He was a Devonian and started his career as a student apprentice with Dartmouth Urban Electric Supply Co. in 1912, having previously studied at Exeter University College for one year. He made rapid progress with his chosen calling and was appointed engineer and manager in 1921. He continued in this position with conscientious courtesy and efficiency for an unbroken period of 38 years—the first three years with the Northwood Electric Light and Power Co. and the remaining 35 years with the Boston and District Electric Supply Co. which was nationalized in 1948.

He was a great character, a hard worker, a robust defender of those things in which he believed and a staunch supporter of his staff, who held him in high esteem. His real hobby was his work although he enjoyed gardening and dabbled in photography.

Lincolnshire will always see a continuing reminder of and a lasting memorial to him in the extensive distribution system spread over the 550 square miles of the Boston district. He will be remembered whenever the east-coast tides rise high or the snows fall heavily. With trouble about he rose to the occasion, and he passed on a grand tradition of public service.

He joined The Institution as an Associate Member in 1925 and was elected a Member in 1942. He served on the Transmission Section Committee from 1945 to 1948. J. P. T.

WALAITI RAM

Dewan Walaiti Ram, who was born on the 20th August 1891, was an invalid for a year and a half prior to his death on the 7th March 1955. He studied at Woodstock School, Mussoorie, India, until 1905 when he went to England and two years later joined Framlingham College, Suffolk, where he was captain of the school cricket, hockey and swimming teams in his final year. He received his technical education at Finsbury Technical College and returned to India in 1913.

He joined the Kapurthala Government as assistant electrical engineer and was appointed electrical engineer two years later. The government was merged, in 1948, into PEPSU (Patiala and East Punjab Union) after India attained independence in 1947. He was chief engineer and secretary, P.W.D. and Industries, Kapurthala, and was instrumental in the establishment of Jagatjit textile mills, Phagwara sugar factory, Jagatjit distilleries, Paramjit sugar factory, Jullundhur Electrical Supply Co., etc. He retired from PEPSU service as superintending engineer (electrical and mechanical) in 1952.

He was a keen cricketer and was honorary secretary of the Southern Punjab Cricket Association from 1930 to 1947, when he was elected president. The Maharaja gave him the title of 'Dewan'. He is survived by his widow.

He joined The Institution as a Student in 1912 and was elected a Graduate in 1919, an Associate Member in 1936 and a Member in 1949. S. N.

PAPERS AND MONOGRAPHS

published individually this month

Papers accepted for reading at meetings, and monographs, are first published individually and are republished later in the Proceedings; as soon as the separates are available they are described in this feature. The papers are supplied free of charge; the price of a monograph is 2s.

In addition reprints of papers read at meetings, including the discussions thereon, and of papers not read at meetings become available, price 2s., within two months of their appearance in the Proceedings.

Applications quoting the serial number of the paper, monograph or reprint as well as the author's name and accompanied by a remittance where appropriate should be addressed to the Secretary. For convenience books of five vouchers for this purpose can be obtained in advance, price 10s.

PAPERS

Frequency variations of quartz oscillators and the earth's rotation in terms of the N.P.L. caesium standard *Paper* 3002 M: *Part B*

L. ESSEN, O.B.E., D.SC., PH.D., J. V. L. PARRY, M.SC., *and* J. McA. STEELE, B.SC.(ENG.)

THE variations in the frequencies of quartz oscillators compared with a caesium standard are described and discussed. The frequencies of the ring-type oscillators at the N.P.L. and other laboratories do not depart from those given by a linear law of variation by more than ± 5 parts in 10^9 over a period of three years.

The quartz oscillators calibrated by the caesium standard have been used to study the variations in the period of rotation of the earth. In addition to an annual seasonal variation of approximately ± 8 parts in 10^9, there was a fairly steady retardation amounting to 1 part in 10^8 in the period between September 1955 and January 1958.

Development of the formulae of electromagnetism in the M.K.S. system *Paper* 3012 M: *Part B*

P. VIGOUREUX, D.SC.

THE use of metres, kilogrammes, amperes, etc. instead of centimetres, grammes, deca-amperes (the C.G.S. units of current), etc. need not change the method of teaching electricity and magnetism for it does not interfere with the notions of magnetic poles and point charges of electricity.

A logical method of developing the theory from conventional experiments on the forces between magnets, between magnets and current-carrying loops, and between electric charges is to proceed from magnetic poles to magnetic shells and from these to loops of current and then bring in the definition of the ampere to evaluate the magnetic constant; consideration of the forces between electric charges follows and, together with identification of rate of change of charge and electric current, leads to the law of induction, to Maxwell's equations, and to wave propagation which, with the known velocity of light, gives the value of the electric constant. The theory is then extended to material media.

A treatment suitable for beginners is outlined.

Theory of the travelling-wave parametric amplifier *Paper* 2991 E: *Part B*

A. L. CULLEN, PH.D.

THE theory of a parametric travelling-wave amplifier is developed, including the pumping wave explicitly. Particular reference is made to two characteristics of such amplifiers which theories assuming a constant pumping-wave amplitude fail to predict.

The first arises from ohmic attenuation in the line and limits the useful line to a length of the order of $(\alpha_1\alpha_3)^{-1/2}$ where α_1 and α_3 are the signal- and pumping-wave attenuation coefficients. Further increase in length leads to a decrease in gain.

The second characteristic is a saturation effect at high signal levels associated with a spatially periodic power transfer between signal and idling waves on the one hand and pumping wave on the other. The maximum power output at the signal frequency is obtainable from the input pump power and the input signal power through the Manley–Rowe relations.

MONOGRAPHS

Frequency-response method for the predetermination of synchronous-machine stability *Monograph* 340 S

A. S. ALDRED, M.SC., *and* G. SHACKSHAFT, B.ENG., PH.D.

A NEW concept is presented for the predetermination of synchronous-machine stability. The concept is based on the realization of a basic closed-loop pattern for a synchronous generator which when established can be subjected to the frequency-response procedure of the Nyquist stability criterion. The basic closed-loop pattern emerges from the application of small-displacement theory to Park's equations for a synchronous generator. The method is applicable to a machine with or without a voltage regulator but is more useful in the latter case, and this embraces the majority of the applications presented.

As a by-product of the analysis, expressions for the damping in a synchronous machine may be derived. The influence of some of the more important parameters of the machine and regulator on the damping coefficient is demonstrated.

Analogue treatment of eddy-current problems involving 2-dimensional fields *Monograph* 341 M

J. ROBERTS, B.SC.(ENG.)

THE author deals with the *RC*-analogue representation of electromagnetic fields involving unidirectional current flow such as those associated with current-carrying conductors lying in armature slots.

The resulting magnetic field is in general 2-dimensional and is fully represented in the analogue. Capacitor current in the latter is directly equivalent to current flow in the corresponding section of the conductor, and the eddy-current loss in a conductor may be calculated from the distribution of current between the several capacitors. Some simple examples illustrate the translation of field-boundary conditions into analogue terms.

Surface-integral methods of calculating forces on magnetized iron parts *Monograph* 342

C. J. CARPENTER, M.SC.(ENG.)

THE force exerted on an iron part in a magnetic field may be calculated by many different methods, all of which give equivalent force distributions confined principally to a surface. Seven different methods giving rise to five different surface-force intensities are shown to result in the same total force. Additional volume-force components are obtained; and a new expression for the actual distribution of force consistent with all the methods of calculation is derived. A common interpretation of the well known Maxwell field stresses in iron is shown to be incorrect.

When the field is specified numerically the calculation of force in terms of surface integrals has certain advantages over the virtual-work method, and simple analytic expressions for force which are usually obtained in this way may be easily derived as surface integrals. Practical applications are considered.

TECHNICAL PUBLICATIONS

FURTHER information and copies of the publications can be obtained from the organizations concerned except where otherwise stated.

BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION

Report A/T144 **Second report on the assessment of the catalyst barrier efficiency of varnish films on copper conductors** 6s. (postage 4d.)

THE behaviour of a limited number of varnishes was described in Report A/T135. Additional varnishes have now been examined, and the work has been extended to cover the behaviour of enamelled copper wires, the varnished cylinder being replaced by a helix of enamelled wire of the same over-all dimensions as the cylinder but having the length of wire adjusted to give the same surface area as that of the cylinder.

Report G/T302 **Selection of test currents and closing angle corresponding to the maximum arc energy in cartridge fuses (440-volt a.c. tests)** by H. W. Baxter. 12s. 6d. (postage 6d.)

THE report explains an investigation to determine the prospective current corresponding to maximum arc energy and to ascertain if this current bears any simple relation to that corresponding to maximum inductive energy. For a given prospective current the circuit closing angle corresponding to maximum arc energy was derived.

Report L/T380 **A survey of dielectric materials** by C. G. Garton. 15s. (postage 8d.)

DEVELOPMENTS since 1951 are reviewed, and an account of progress in some methods of insulation testing is given.

Report M/T132 **Testing of screened enclosures** by J. Miedzinski. 24s. (postage 8d.)

THE author shows various methods of testing and outlines the properties of insertion loss. Particular stress is placed on the dependence of insertion loss, as measured practically, on the details of experimental arrangement as well as on the test frequency and the construction of the enclosure.

Report O/T21 **Wide-range recording anemometer** by A. N. Rapsey. 9s. (postage 6d.)

THE anemometer discussed was developed for investigating mechanical vibrations caused by the action of wind on the conductors of overhead transmission lines. Although there was no interest in wind speeds above 25 m.p.h. the instrument will in fact measure as well as withstand wind speeds up to 100 m.p.h. The anemometer, of the windmill type, is a modification of one described in Report C/T114 (February 1957 *Journal*, p. 117).

Report V/T136 **A double-exponential-waveform generator for model networks** by P. G. Kendall. 7s. 6d.* (postage 6d.)

A GENERATOR of double-exponential waveforms for the study of lightning surges on a network analyser with frequency modelling is explained.

BRITISH ELECTRICAL AND ALLIED MANUFACTURERS' ASSOCIATION INCORPORATED

Publication No. 159 **Abbreviations of associations, institutions, research and trade associations** London, revised edition, 1959. 1s.6d.

THIS useful booklet includes lists of suffixes and qualifications and of abbreviations of international and oversea organizations.

* Extra copies 2s. 6d. each

BRITISH ELECTRICAL DEVELOPMENT ASSOCIATION

Farm Electrification Handbook No. 5 **Grain drying. A guide to the practical design of installations** London, 1959. not priced

A SUMMARY of the basic principles of grain drying is followed by outlines of the different types of dryer available and guidance as to the choice between them.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

Cmd. 739 **Report of the Research Council for the year 1958** London, H.M.S.O., 1959. 3s. 6d.

DETAILS are given of the expenditure on individual grants, D.S.I.R. research stations, and grant-aided research associations. Descriptions of information and library facilities, oversea liaison, and studentships are included. Patents accepted and applied for during the year are listed in one of the seven appendices.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH: RADIO RESEARCH

Special Report No. 27 **The calculation of the median sky wave field strength in tropical regions** London, H.M.S.O., 1959. 2s. 6d.

THE characteristics peculiar to low-latitude propagation are summarized and the principles of the prediction system described, taking advantage of recent research. The presentation of the prediction equations in nomogram form enables the median field strength to be computed for ranges of 0–4000 km to any epoch in the solar cycle. The range can be extended as required. Curves are given showing where aerial polarization may be important.

ILLUMINATING ENGINEERING SOCIETY

I.E.S. Technical Report No. 1 **Lighting in corrosive, flammable and explosive situations** 5s. (postage 6d.)

THE report deals with hazards of explosion and fire which might arise in lighting fittings and with some conditions of corrosion affecting safe operation. Certain safeguards in the electrical supply system are suggested.

Forthcoming events

ALL meetings are held at Savoy Place beginning at 5.30 p.m. (tea at 5 p.m.) except where otherwise stated. The nature of the meeting is indicated by the following key:

E ELECTRONICS AND COMMUNICATIONS SECTION
M MEASUREMENT AND CONTROL SECTION
O ORDINARY
S SUPPLY SECTION
U UTILIZATION SECTION

September 1959

S **10–13** *Thursday–Sunday* Section visit to Dublin

October

O **8** *Thursday* SIR WILLIS JACKSON, D.SC., D.PHIL., DR.SC.TECH., F.R.S. Inaugural Address as President† (Place of meeting to be announced later)

M **13** *Tuesday* PROF. A. TUSTIN, M.SC. Chairman's Address†

U **15** *Thursday* T. E. HOUGHTON, M.ENG. Chairman's Address†

S **21** *Wednesday* J. R. MORTLOCK, PH.D., B.SC.(ENG.). Chairman's Address†

E **28** *Wednesday* M. J. L. PULLING, C.B.E., M.A. Chairman's Address†

This is not the complete list of meetings to be held during October

† No advance information will be available

SOME RECENT BOOKS

J. J. HAMILTON
REFLEX KLYSTRONS

CHAPMAN AND HALL. 1958. 260 PP. £2 5S.

HERE is a volume which can be recommended for its unpretentious authority. Although the treatment is modest in level the amount of information presented is large, and the microwave engineer looking for general guidance on the use and performance of reflex klystrons will welcome the book. He will find it pleasant and rewarding to read.

The first two chapters give a useful summary of principles and by using equivalent-circuit representation explain the network behaviour of output-coupling circuits and tuning mechanisms. Next follows the standard small-signal theory using electron dynamics, with appropriate comments on the limitations of the theory. Complex admittance load effects based on the Rieke-diagram techniques occupy chapter 4, and chapters 5 and 6 consider the practical problems of manufacturing the devices and describe the electrical and mechanical characteristics of a representative range of existing valves. The short final chapters on unconventional types and on future trends are not very valuable and were hardly worth including.

The analysis is fairly simple, but the work contains stimulating physical knowledge about the obscure aspects of the behaviour of reflex klystrons with hints of the methods of attack of the more advanced theories. It is a very nice survey, well composed and produced.

S. H. HOLLINGDALE
HIGH SPEED COMPUTING METHODS AND APPLICATIONS

ENGLISH UNIVERSITIES PRESS. 1959. 244 PP. 25S.

THIS is a well written elementary account of high-speed computing machines, and although the author does not quite succeed in the task which he proposes in his preface it will still have considerable appeal to the non-specialist reader and can be recommended.

The first three chapters deal with the basic ideas of machine calculation, the representation of numbers in binary and other scales, and the fundamentals of programming. Chapters 4 to 6 trace the history of actual machines from Babbage to the Edsac and the Deuce, the latter machines being treated in considerable detail from the viewpoint of logical structure.

Engineering considerations are mentioned in the most general terms in chapter 8, only sufficient detail being given to enable the general reader to see that for example, a magnetic drum could store information, but without the specialist detail required to show how it does. There is a short chapter on logical design and an interesting relation of the operation of a computing centre. The reviewer was particularly envious of the large staff which the author commands and which is detailed on p. 167.

The last four chapters are curiously arranged. Chapter 10 discusses applications in mathematics, science and technology and is followed by a clear but oddly isolated chapter on the Monte Carlo method. The latter is particularly unexpected because it forms almost the only detailed exposition of numerical analysis in the volume. As if by an afterthought the work ends with chapters on process control and a programmed milling machine and on machine translation of language.

The book is well produced and contains few misprints. There is a useful bibliography which, because of a set of 'additional references', suggests that the publishers took some time in their task.

R. F. HARRINGTON
INTRODUCTION TO ELECTROMAGNETIC ENGINEERING

McGRAW-HILL. 1958. 312 PP. £3 2S.

THIS is a baffling work. Harrington states in the preface that he has written an introductory textbook for junior, senior or first-year graduate students. This would correspond to a B.Sc. course in electrical engineering in this country. Yet the style of the treatment is of such difficulty that only a graduate in mathematics could read it with any degree of comfort.

The author declares his intention of drawing on the knowledge of circuit theory already acquired by engineering students. Any experienced teacher would agree that it is essential to introduce the unknown by means of the known, but the author does not carry out his intention. He makes very little reference to circuit theory.

Again he states that 'physical concepts are used in place of abstract mathematics wherever possible'. The book is however almost devoid of physical concept, and abstract mathematics is dominant. If the title were changed to 'Mathematics of electric and magnetic fields' it would describe the contents correctly.

As a mathematical text it is carefully written and will appeal to some teachers and research workers in mathematical physics.

J. V. JELLEY
ČERENKOV RADIATION AND ITS APPLICATIONS

PERGAMON PRESS. 1958. 304 PP. £3 5S.

THE development of microwave techniques during and since the Second World War has brought much of physical optics into the province of the radio engineer. Thus the concept of diffraction in aerial theory and the idea of slow waves in travelling-wave tubes and accelerators are now well established. Those working in such fields should find much to interest them in Dr. Jelley's book.

The most important application of the Čerenkov effect is to the detection of high-velocity charged particles and in the measurement of their energy, and half the volume is devoted to the design of such detectors. The other half is less specialized: it contains a readable exposition of the basic theory first put forward by Frank and Tamm just over 20 years ago and a comprehensive review of the refinements, extensions and generalizations which have been made since then. Experimental work both in the optical and in the microwave region is also covered.

The possibility of using the phenomenon or its inverse for generating microwaves or accelerating particles is touched on, but it is as much for the insight to be gained into radiation phenomena that the work will be of interest to the radio engineer. At its price not many engineers will want to buy it, but there should be a copy in every scientific library.

T. L. MARTIN

PHYSICAL BASIS FOR ELECTRICAL ENGINEERING

MACMILLAN. 1958. 410 PP. 30S.

THE fundamental nature of materials which has been the proper study of the physicist is now, because of an increasingly versatile technology, rapidly exploited in electrical devices. The electrical engineering student and his teacher are thus faced with the problem of studying advanced and diverse concepts concerning the microscopic structure of matter alongside the usual studies of circuits and fields, with a scarcity of appropriate textbooks. In such a situation this work may be confidently recommended. The author shows considerable skill in providing an introduction to the subject which is logical, consistent and eminently readable.

Conciseness is achieved by omitting experimental methods and explanatory analysis. The latter omission is sometimes unfortunate since it can mask the validity and derivation of the final laws. A condensation of the opening chapters on electromagnetic theory which is already adequately treated in a host of books and the inclusion of more analysis in the later chapters might enhance the work's value therefore. For similar reasons sections dealing with resistance and capacitance combinations, inductance, magnetic circuits, etc. seem trivial and could be omitted.

The structure of the atom, including the nucleus, is discussed clearly, and an account is given of the band-theory model for solids. This is used to explain the electronic behaviour of metals, semiconductors and transistors. Electron emission introduces vacuum and gas tubes, the latter topic being prefaced by a brief discussion of gas-discharge processes. Magnetic properties are well summarized, and there is a chapter on insulators which might perhaps be improved by more information on dielectric behaviour.

Criticism should not obscure the fact that here is a successful attempt to provide an inexpensive volume on electrical-engineering materials. The diagrams are adequate, and selected references are provided. Problems at the ends of the chapters are really simple numerical examples, but they give an opportunity for the reader to assess the magnitudes of the quantities and units involved.

K. A. PULLEN, Jun.

CONDUCTANCE DESIGN OF ACTIVE CIRCUITS

NEW YORK: RIDER. LONDON: CHAPMAN AND HALL. 1959. 330 PP. £4

THIS volume is rather unusual in its arrangement as the author has tried to make it useful to various types of reader. The opening chapter on 'Basic principles' begins with Ohm's law, and a full-page table of values is given to show without differentiating that if the current through an inductance is a sine function the voltage across it will be a cosine function. Yet a few pages further on matrices are introduced.

The main theme is the use of a method devised by the author for designing valve and transistor circuits. The constant-current form of equivalent circuit is used, and curves of constant conductance and mutual conductance are superimposed on the usual characteristics. Load lines are drawn in the usual way, but the distortion for large-signal operation is estimated by comparing the small-signal behaviour at several points on the load line instead of by comparing the intercepts on it.

The design of amplifiers, cathode-followers and sine-wave and relaxation oscillators is treated by this method, and many numerical examples are given. There is a good deal of practical information on components, limitations of valves, lay-out of amplifiers, and so forth. The bibliography comprises only papers by the author on his design method.

It is evident that the author is a practised designer of electronic circuits, but the book is difficult to read. The author gives the impression that before he developed his methods, there was little logical design of electronic apparatus.

P. C. SANDRETTO

ELECTRONIC AVIGATION ENGINEERING

INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION. 1958. 772 PP. £3

FOR the benefit of the great majority of potential readers, the author starts his preface with a pedantic explanation that 'navigation' is for conducting ships but 'avigation' is for conducting aircraft. However, absurdities appear later such as 'The early airborne electronic equipment [was] used to avigate by pilotage . . . later . . . equipment was produced solely for navigational purposes.' This reviewer found the use of 'avigation' irritating.

The preface states that 'only devices . . . actually in use or . . . [which] have had some recognition by aviation policy-making bodies will be described' and that the subject-matter may become obsolete as a result of declassification of military equipment rather than through changes in the field. The impression gained is that most of the text was completed several years ago; and although for example a chapter on TACAN has been included as well as a few paragraphs referring to new systems the work as a whole suffers from a lack of clear differential between those systems in widespread use for civil and military purposes and those which are only projected. Some of the latter have indeed since been discarded. This is not of importance to those familiar with the subject but is misleading to others.

It is a little difficult to decide what type of reader the author had in mind as the book is not detailed enough for a systems engineer or equipment designer and contains for the general reader too much detailed circuitry. There is further evidence here of the dating of the text as no mention is made of the application of transistors.

There are a number of omissions and errors, some of which are referred to by the author such as Doppler and ATC transponders. There is for example no mention of fixed-loop ADF; and in the chapter on electronic pilotage equipment P.P.I. stabilization is ignored; 200 Mc/s D.M.E. and 50 cm ground radar, both in widespread use, are also left out.

In spite of the foregoing criticisms the volume is so far as the reviewer is aware the only one dealing comprehensively with the subject. Each chapter ends with a useful bibliography although again very few of the references are more recent than 1950.

J. SHEPHERD, A. H. MORTON and L. F. SPENCE

HIGHER ELECTRICAL ENGINEERING

PITMAN. 1958. 566 PP. £2

THIS one-volume work is designed to cover the electrical-engineering content of the A.1 and A.2 years of a Higher National Certificate course. It follows on from 'Basic electrical engineering' by the same authors. The coverage of this well defined and important field in a single volume would alone justify this addition to an already considerable literature at this level. It will be found to be acceptable also

in many university and other full-time courses as an intermediate-standard text which will cover a substantial portion of the pre-final-year electrical work.

The selection of the material, its arrangement and presentation are excellent and reflect the authors' experience of teaching the subject. The book can be divided into three roughly equal sections. The first deals with fundamental matters including networks, harmonics, transients, and electric and magnetic fields. The second and third sections are devoted to 'heavy-current electrical engineering' and 'electronics' respectively.

Within the limited compass available for each section the choice of material is good. One notes particularly the agreeable way in which the various aspects of parallel operation of electrical equipment are brought together to emphasize the common principles involved instead of as so often happens treating this problem separately and wastefully for transformers, transmission lines and other devices.

The text is liberally illustrated by well chosen and clearly presented line diagrams. Illustrative worked numerical examples are used throughout without however destroying the sense of arrangement and continuity. A reasonable range of examples (with answers) is provided at each chapter end.

C. SINGER, E. J. HOLMYARD, A. R. HALL and T. I. WILLIAMS (*Editors*)

A HISTORY OF TECHNOLOGY. VOL. 4—THE INDUSTRIAL REVOLUTION, *c.*1750–*c.*1850

OXFORD. 1958. 728 PP. £8 8s.

IN this history, technology is treated in the widest possible sense, and 22 out of its 23 chapters deal in considerable detail with almost every practical aspect of living in a modern industrial state such as: farming, fishing, mining, and associated processing; building, water supply, and drainage; roads, canals, cartography, shipbuilding, and the telegraph; water, wind and steam power; and primary and secondary manufacturing.

The dating is elastic so that the early stages of many developments have been included to give a consecutive narrative. The telegraph's story continues to about 1870 and that of roads to 1900.

Although it is a work of composite authorship a consecutive thought runs through all the sections which is summed up in the final chapter on the scientific basis of technology. This connecting thread shows how a developing science allied itself to the traditional skills handed down from the old craft guilds and to the apparently instinctive genius of many of the early pioneers and so made modern industry possible.

Joseph Black (1725–99), Professor of Chemistry at Edinburgh, may be taken as one example of a scientist of ability and repute who did much to lay the foundations of the British chemical industry, the width of his interests being shown by the way he assisted James Watt not only with scientific and technical advice but by useful commercial introductions.

While the entire volume should be of interest to the electrical engineer there is relatively little which refers directly to his subject. During the period reviewed most of the fundamental electrical facts were discovered—Volta's primary battery for example appeared during 1800, exactly in the middle of it—but applications had to await a later epoch.

The exception is telegraphy, and a fascinating story is told of the early visual telegraphs, experimental methods employing electrostatics and finally the successful work of Cooke and Wheatstone. It may come as a surprise to learn that the first systems which actually operated in 1837 utilized multicore cables and not overhead lines. A touch of sadness is introduced by the official reaction to Ronald's offer to demonstrate his equipment in 1816 when he was informed by the Admiralty that 'telegraphs of any kind are now wholly unnecessary'.

The inevitably small amount of information on electrical matters makes any omissions unduly conspicuous, and it seems surprising that no mention is made of Davy's demonstration of the arc light in 1809, the long series of permanent-magnet generators which started within a year or two of Faraday's discovery of electromagnetic induction in 1831, or the electric motor of the Russian, Jacoby, which actually propelled a boat in 1845. Particularly puzzling is the absence of Kelvin's name in the chapter on telegraphy, for his work on conductor resistance was essential to the success of the transatlantic cable.

Although the Industrial Revolution started in Britain many fundamental scientific discoveries and technical developments were made outside the 'workshop of the world' both in Europe and in America; and even before 1800, British engineers studied foreign languages and travelled oversea to keep up to date. This internationalism is reflected by the authors from France and Holland among the team.

Like all good technical histories it is readable and interesting; it presents a convincing demonstration of the essential unity of science and the arts, but its particular value lies in the fact that it answers 'why' industrial operations are carried out in certain ways. A man who knows 'why' is likely to go further in his profession than one who is concerned only with the utilitarian 'how'.

E. G. STANFORD and J. H. FEARON (*Editors*)

PROGRESS IN NON-DESTRUCTIVE TESTING—VOL. 1

HEYWOOD. 1958. 267 PP. £3

A NON-DESTRUCTIVE measurement of almost any physical property of an object provides some information which may or may not be useful about the constitution or condition of the body tested. It is therefore not surprising that this volume, the first of a proposed annual series of critical progress reviews, covers subjects as disparate as stress-wave propagation and the measurement of electrical potentials in the human body. The appeal of non-destructive methods in the latter case will be clear even to the lay mind. Covered also in eight reviews by as many authors are radiography by X-, γ- and neutron irradiation; eddy-current testing; mechanical damping; thermal conductivity; and nuclear magnetic resonance.

The text written throughout by physicists is concerned mainly to establish the physical bases and capabilities of the methods described. Details of established industrial tests and apparatus are only incidentally mentioned. The authors have thereby had scope to discuss those phenomena which are powerful tools in revealing the nature and structure of materials on an atomic and larger scale, whether or not these have yet found wide application in industry.

The engineer will find this not only a thorough guide to the theory of such methods as eddy-current testing which he may already employ but an active stimulant to devising new practices and applications. He will also derive from it much

knowledge of the physics of solid materials. The advanced engineering student with some background of physics will similarly find the work helpful in filling the lacuna concerning the physics of materials which still exists in many engineering courses.

The electrical engineer may regret that this first volume gives no specific attention to tests on insulating materials; this need may well be supplied in future reviews.

The book is pleasantly produced at a reasonable price. The only misprint noticed (Fig. 4 of chapter 4) is a rather pleasing confusion of neutron with Newton! They are of course alike in their powers of penetration.

H. W. SWANN

ELECTRICAL SAFETY

MACDONALD. 1959. 292 PP. £2

THERE is probably no one better qualified to write on electrical safety than H. W. Swann who gives in this volume the results of a life-long study of the subject. It should be of general interest to advanced students and engineers engaged in the utilization of electricity and be particularly useful to safety engineers, including factory inspectors, insurance surveyors and industrial safety officers.

The first seven chapters are based on the Factory Electricity Regulations and are largely devoted to shock risk. There is a wealth of practical detail including descriptions of actual incidents which help to make the topics easy to understand.

The other side of electrical safety, namely fire risk, is not treated in the same comprehensive manner. There are some important omissions including the fire hazard of various types of heating appliances, lamps and cables. However, the eighth chapter 'Inflammable surroundings' deals with the fire risk in a number of special industrial locations.

The last chapter on static electricity is a useful contribution because little has previously been published on this matter. There is an appendix consisting of the author's Institution paper on 'Domestic electrical installations—some safety aspects' which contains valuable ideas on some of the causes of fire in domestic premises.

J. VOGE

LES TUBES AUX HYPERFRÉQUENCES

PARIS: EYROLLE. 1959. 260 PP. £4 6S.

W. J. KLEEN and K. PÖSCHL

EINFÜHRUNG IN DIE MIKROWELLEN-ELECTRONIK—VOL. 2

STUTTGART: HIRZEL VERLAG. 1958. 192 PP. £2 7S. 6D.

J. VOGE has written a description of the operation of most of the electron devices used at microwave frequencies. These include gridded valves, klystrons, and travelling-wave tubes. An appendix discusses parametric amplifiers and masers together with recent work on low-noise travelling-wave tubes.

The book starts with a chapter on the theoretical bases for the interchange of energy between fields and electron beams, but the relations developed are little used. The mathematical relations derived in the main text are essentially of the first order. For instance in the section on klystrons the gap-coupling coefficient and the gap-loading factor are ignored.

The work is thus more useful to the user of microwave tubes than to the designer, particularly since a good deal of space is devoted to summarized characteristics of existing tubes. The appendix is a recital of results achieved mainly in the United States on a wide variety of devices.

The book by Prof. Kleen and Dr. Pöschl is Vol. 2 of a three-volume work. Vol. 1 which was originally published in German in 1952 has recently been translated into English in a revised version ('Electronics of microwave tubes' by W. J. Kleen. Academic Press: 1958). The volume under review deals with all types of electron-wave tube, roughly two-thirds of the content being devoted to travelling-wave tubes while the remainder deals with backward-wave oscillators, double-stream amplification, resistive-wall amplifiers and other special electron-wave devices. Appendices cover the helix considered as a periodic-delay line and problems of focusing axial symmetric electron beams.

Frequent reference to Vol. 1 is necessary if the development is to be fully understood, but specialists in valve design will find this work very useful. The extensive bibliographies are especially commendable. It is to be hoped that this volume will be translated in due course.

D. C. WHITE and H. H. WOODSON

ELECTROMECHANICAL ENERGY CONVERSION

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1959. 646 PP. £5

THIS volume is one of several resulting from the 'core curriculum' electrical engineering programme of the Massachusetts Institute of Technology. In the M.I.T. view courses built round separate regions of industrial practice and current technology should be subordinated to a common broad-based 'core' of basic principles and analytical methods allied to a new laboratory programme.

Such a view is not confined to the M.I.T.: the preface echoes statements that have in the recent past been made repeatedly over here by a few enlightened cranks. Electromechanics is considered to be the cornerstone of electrical engineering (with the partial exception of electronics). The starting-point is Hamilton's principle to obtain the equation of motion of a given system. Analysis by steady-state concepts and elementary networks is considered to be unreal; and on a basis of lumped-parameter analysis the general equation of motion is derived with a preference for Lagrangean methods which can be adjusted to include the non-conservative parts of a system.

The treatment is advanced, comprehensive and scholarly. Some attention is first devoted to general electro-mechanical systems and transducers, and several techniques are then presented for their analysis. Some of these are familiar (such as the log-modulus and transfer-function analyses), others less so. The last eight chapters deal with the dynamics of transducers, feedback control systems and rotating electrical machines. In the latter case the two-reaction concept is adopted (and here called '2-phase') using the transformations made familiar by Gibbs, Adkins and of course that prodigy Gabriel Kron. There are a few examples in the text and several sets of problems (but no answers).

The foreword suggests that the book is not considered outside the ambit of undergraduate students. Such students will have to be quite exceptional in their ability and maturity. The work is certainly not for 'the practical engineer' either, but it will deeply interest the younger professional engineer who has not yet forgotten his mathematics and can appreciate the unique qualities of this comprehensively analytical text with its bold integration of the electrical and the mechanical.

LIBRARY ACCESSIONS

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members*

BOOKS

AMOS, S. W. 621.314.7

Principles of transistor circuits. Introduction to the design of amplifiers, receivers and other circuits*

London and New York, Iliffe and Sons, 1959. pp. viii, 167. 22 × 14cm. 21s.

An introduction to the design of transistorized equipment, dealing with the determination of input resistance, stage gain, optimum load, power output and other practical matters. This book will be reviewed in a future issue.

BOUMAN, P. J. 92 (PHI)

Anton Philips of Eindhoven

London, Weidenfeld and Nicolson, 1958. pp. 255. 22 × 14·5cm. 30s.

An interesting and very readable account of the life of Anton Philips, one of the two brothers who founded the great Dutch firm, interwoven of necessity with the progress of the firm itself. It traces events from the early days of the electric-lamp industry through two world wars to 1951 when Anton Philips died.

DONALDSON, P. E. K. 612:621.3

Electronic apparatus for biological research

London, Butterworths, 1958. pp. xii, 718. 25 × 16cm. £6

A simple theoretical introduction to components and circuit-elements is followed by a section on construction of equipment. Transducers and indicators for various applications are then discussed as well as complete equipment for various purposes. Reviewed in May 1959 *Journal*, p. 321.

DUMMER, G. W. A. 621.38

Modern electronic components*

London, Pitman, 1959. pp. viii, 472. 23 × 14cm. £2 15s.

This work is intended to be a reasonably comprehensive summary of essential data on electronic components. It covers resistors, capacitors, wires and coverings, r.f. cables, plugs and sockets, relays, switches, inductors and magnetic materials, and batteries. The performance of components in tropical and in Arctic conditions is also dealt with. Bibliographical references are given at the end of each chapter. Reviewed in May 1959 *Journal*, p. 322.

FREEBODY, J. W. 621.394

Telegraphy

London, Pitman, 1958. pp. xii, 738. 25·5 × 19cm. £4

This book which is a successor to T. E. Herbert's 'Telegraphy' is a detailed treatment of principles and practice and in particular of systems and equipment used by the British Post Office for the inland and oversea public service, for private wires and telex. While concerned mainly with practice since the reorganization in the 1930's it includes a historical survey. The chapter on telegraph transmission theory is essentially the text of E. H. Jolley's book published in 1947. Reviewed in May 1959 *Journal*, p. 323.

GANT, H. N. 621.396.931

Mobile radio telephones. An introduction to their use and operation*

London, Chapman and Hall, 1959. pp. 125. 22 × 14cm. 21s.

It is intended for the layman rather than for those concerned with design or maintenance and explains the uses and limitations of mobile radiotelephone systems. Performance requirements, siting and installation considerations and maintenance are discussed.

HIRST, A. W. 537

Electricity and magnetism for engineering students. 3rd edition*

London, Blackie and Son, 1959. pp. xiv, 438. 22·5 × 15cm. £2

A textbook for electrical engineering students on courses of intermediate examination standard. In this edition the M.K.S. system is used, and the text has been extensively revised throughout.

HIX, C. F., Jun., and ALLEY, R. P. 53 (03)

Physical laws and effects

London and New York, Chapman and Hall, 1958. pp. 291. 23 × 15cm. £3 4s.

Gives brief information on familiar and unfamiliar laws and effects arranged alphabetically by name with cross-references under physical quantities and under scientific subject groups.

KENDALL, M. G. (*Editor*) 338

The sources and nature of the statistics of the United Kingdom—Vol. 2

London, Oliver and Boyd, 1957. pp. viii, 343. 26 × 19cm. 30s.

A further 19 articles by acknowledged authorities indicating the statistical information available in the United Kingdom relating to various industrial fields.

LAGO, G. V., and WAIDELICH, D. L. 538.551

Transients in electrical circuits*

New York, Ronald Press, 1958. pp. vii, 393. 24 × 15cm. £3 14s.

For students familiar with the differential and integral calculus and who have had at least an introductory course on electric circuit theory. Reviewed in December 1958 *Journal*, p. 681.

QUERFURTH, W. 621.318.4

Coil winding. 2nd edition*

Chicago, Stevens, 1958. pp. 192. 22·5 × 14cm. £2 12s.

A practical work on coil-winding procedures, machines and associated equipment. It deals with single and multi-layer coils, universal and toroidal windings, and yoke and armature winding.

RUDNER, M. A. 679.5

Fluorocarbons

New York and London, Chapman and Hall, 1958. pp. viii, 238. 19 × 13cm. £2 6s.

Describes briefly the unusual properties, chemistry, method of manufacture and applications of the fluorcarbon materials. Sufficient information is given to indicate to the potential user where these materials may be employed with advantage.

VAJDA, S. 519.2

The theory of games and linear programming*

London and New York, Methuen, 1958. pp. 106. 17 × 10·5cm. 8s. 6d.

A systematic and comprehensive account of a new branch of applied mathematics based on algebraic concepts. It develops the argument from first principles and incorporates accounts of recent advances in this rapidly developing field. Examples are given of situations mainly of an economic nature in which linear-programming methods have proved of value.

WAKEFIELD, G. G. (*Editor*) 629.135

Aircraft electrical engineering*

London, Chapman and Hall, 1959. pp. xiv, 349. 26 × 15cm. £2 10s.

Based on a series of lectures given in 1954. Environmental conditions and functional requirements are discussed including the behaviour of brushes at high altitudes, the effects of vibration and the cooling of machines. Both a.c. and d.c. equipments are dealt with, and there is a chapter on future needs. This book will be reviewed in a future issue.

WELCH, G. B. 621.392

Wave propagation and antennas*

New York, Van Nostrand, 1958. pp. 257. 23·5 × 15·5cm. 43s. 6d.

Intended to provide for students a background knowledge of electromagnetic wave propagation and the fundamental principles of antennas and waveguides. This book will be reviewed in a future issue.

WILLIAMSON, J. J., and BUCKLE, P. A. F. 614.84

Fire extinguishment and fire alarm systems

London, Pitman, 1958. pp. xii, 240. 22 × 14·5cm. 30s.

This account will be of interest as a comprehensive yet concise review of fire-precaution equipment in buildings. It contains a chapter on fire alarms.

The following elections and transfers approved by the Council are effective from the 25th June 1959

Elections and transfers

ELECTIONS *Graduates*

AGARWALA, Ram Niranjan
AKTEKIN, Ismet, M.SC.
ALEXANDER, John David Henry, B.SC.(ENG.)
ALI, Syed Akhtar
AMOR, John Francis, B.E.E.
ASPINALL, Roy
ATKINSON, Derrick William
ATWOOD, Reginald Frederick Thomas
AYLES, Francis Anthony
BELL, Colin Peter, B.SC.
BENAR, Albert Nisim, M.SC.
BOSE, Sanjit Kumar, D.F.H.
BREWSTER, Kenneth, B.SC.
BROCKWELL, Peter John, B.E.E.
CARRE, Bernard Albert, B.A.
CHATTERJEE, Basudebananda, B.SC.
CLARK, David Andrew, B.E.
CLEMENTS, Michael Francis
CRADDOCK, Alan Frederick, B.SC.
CRAWLEY, Denis John
CRAXFORD, Samuel Charles, B.A.
CREW, Gregory Leonard, B.E.
DASGUPTA, Kalyansri, B.E.E., PH.D.
DAVENPORT, Peter Bradburn, B.E.
DAVIDSON, James Anthony
DEMETSOPOULLOS, Ioannis Christou, M.SC.
DOWNING, David William, B.SC.
DUNNE, Graham Vincent, B.SC., B.E.
EDMONDSON, Brian Peter
ELEY, Robert George
ENGLISH, Geoffrey Bryan
EVANS, Thomas
FENELON, Louis Jens Paul, B.E.
GARRETT, Gerald Stanley
GIBSON, Ronald Henry
GORDON, Alan, B.SC.
GRAY, Frederick Martin, D.F.H.
HARRISON, Terrence Trevor
HEAL, Noel Frederic, B.E.
HENSBY, Walter William Shakespeare
HIGGINS, John Aidan, B.E.
HOBSON, Thomas Alfred, B.A.
HOUSTON, Barry Thale
HUDSON, Gordon Charles, B.A.
HUGHES, Kenneth George
IBBOTSON, George Derek
JONES, Bernard Joseph, B.SC.
KEY, Brian Douglas, B.SC.(ENG.)
KNIGHTS, Harold John
KOUNTOURIS, George Loizou, B.SC.
LEWIS, David John
LOOKMANJI, Mushtaq Ali, B.SC.(ENG.)
LUNN, Gerald John
MCCARTHY, Edward Prague, B.E.
MCKAY, Brian Francis
MASRI, Munther Wasef, B.SC.(ENG.)
MATTHEWS, Andrew Raymond
MAYNARD, Lewis Maxwell, B.E.
MOHAN, Virendra, B.SC.
NAYERI, Iraj, D.F.H.
O'DONNELL, Patrick Joseph, B.E.
O'SHAUGHNESSY, Thomas Arthur, B.E.
PEAT, Raymond Stanley
PENDLEBURY, Bernard, B.SC.(ENG.)
PICCAVER, Malcolm John
PURI, Om Parkash, B.A., B.ENG.
REVILL, William Gordon Wilson, B.SC.(ENG.)
RIVES, Ricardo Guillermo
ROBBINS, Frederick Michael
ROBERTS, John Leonard
RORK, George Douglas
RUSSELL, William Hugh John, B.SC.(ENG.)
SCOTT, Neville Gordon
SENEVIRATNE, Nanayakkara Liyanage Gnanadasa
SHEPPEY, Gerald Clive, B.A.
SIMMONS, William Lawrence
STAFFORD, Robert William Howard, B.A.
THORNE, Herbert Stanley
TOSCANO, Mario Manuel Mantua
WARWICK, Richard Geoffrey, B.A.
WHITTLE, Jack
WILLIAMS, John
WIN, Maung, B.SC.
WINDSOR, Trevor Charles, B.SC.
WOODBRIDGE, Robin Michael, B.A.

Students

ABBISS, John William
ADEBARI, Sunday Akinsola
ANSARI, Abdul Jamil
AUSTIN, William
AVGHERINOS, Robert Constantine
BAILEY, Cyril
BARDEN, Kevin Reginald
BEAN, John
BECK, George Morland, B.A.
BESANT, Colin Bowden
BICKLEY, David Thomas
BOLTON, Brian
BOUCHER, Richard Desmond Greer
BRAMALL, John Reginald
BRAY, John Harris
BRETT, Richard Gordon
BRONZITE, Michael, B.SC.
BROWN, Michael Edward Cyril
BRYANT, Christopher
BURTON, John
CHILD, Michael
CHIN, Lit Yan
CLEGG, Michael Arthur
COLACO, Claude Anthony
COLLET, Robert Thomson
COPPOCK, Ronald George
COWLEY, Alan
COX, Bernard Ronald
CRANE, Robert
DALE, Anthony Peter, B.SC.
DAWSON, Colin Tasman
DE LE GUERRE, Petrus Morney
DIAS-LALCACA, Francis Severino
DICKINSON, Thomas Benjamin
DIGHT, John Peter Wilton
DODDS, Ian Matthews
DOWELL, Peter Lewis
EVANS, Kenneth Stuart, B.SC.
EVANS, Michael Gareth Kiloh
FAHMY, Mostafa Nooreddin Ismail, B.SC.(ENG.)
FLACK, Laurence Edmund
FLETCHER, Michael Anthony
FORSYTH, Donald Keith
FOWLER, Donald Geoffrey
GARVIN, Michael John
GEORGE, Enyr
GIAM, Choo Huat
GIBBON, Robert Roger, B.SC.
GIGGINS, Anthony Charles
GILL, John Oliver
GILL, Tara Singh
GODIER, Roy Frederick, B.SC.
GOVENLOCK, Terence Edmund, B.SC.
GRANT, Alasdair Ruari
GUHA, Asoke Kumar, B.SC.
HALL, William
HANLEY, Gordon Alfred
HARTLEY, Edmund John Ridgard
HATHAWAY, Brian Leslie
HAWKINS, Harold James
HEAL, Alan Gerald
HEY, Peter
HIGGINBOTTOM, Roy
HOARE, John Edward
HOLT, David Malcolm
HOME, Nickolas Peter Carter
HOPTON, Geoffrey James
HORSLER, Gordon Barry
HOSIER, Alan John Gordon Stanley
HUGHES, Thomas George
HUMMEL, John Rex
HUNT, Dudley Reginald
IBRAHIM, Badreldin
INMAN, Lionel John
JONES, Bernard
KEIR, Alexander Stuart
LEE, Yee Cheong
LEGGETT, Clive Alan Arthur
LINNELL, David Gerald
LISTER, Robert Malcolm
MCCLEAN, Marianna Inez
MCGEE, Brian Patrick
MALHAN, Chand Kishore
MANLEY, John William
MATTHEWS, David Harry
MERRITT, Malcolm Lionel
MORRIS, Douglas Ian
MORTON, Brian William John
MULKI, Arvind Shivram
NAIR, Narayana Janardanan, B.SC.
NARAYANAN, Mandyam Ananda
NAYLOR, Antony George, B.SC.
NEWDIGATE, Robin Francis
PACKER, Timothy John
PARIKH, Praful Sakerlal
PEDDER, Richard Anthony Tyrrell
PENNY, Raymond William, B.SC.
PERERA, Withanage Sebastian Anthony
POPE, David Stanley
POWELL, William Hugh
PRESTON-WHYTE, Robert James
QUINN, Brian
RAJARAMAN, Thiagarajan, B.E.
RAMASESHU, Kasarabada, B.SC.
RICHARDS, Andrew John David
ROBSON, George Geoffrey
ROFE, Digby Edwin
RYAN, James Patrick
SACKMAN, Peter Michael
SANCROFT, John Edward
SANDERSON, George
SANGRAR, Abdul Rahim
SHAH, Sitaram
SIMPSON, John Raymond
SKELTON Kenneth Victor
SMITH, Brian Frederick
SMITH, Thomas Edward
STARLING, Anthony Roger
TAYLOR, Maurice
THADANI, Kishin Lakhi
THOMAS, Philip Wilfred
TREWICK, Malcolm
TUCKER, James Henry
TWAITES, Brian Peter
VAN DER RIET, David Benedict Otto
WEST, Roger
WHITING, John Percy
WILEBORE, Derek
WILLIAMS, John Gwyndaf
WILLIAMS, Robert George
WOOD, Ivor Thomas
YALDEN, Michael Edward

TRANSFERS *Student to Graduate*

AL-SAIGH, Jamil Bashir Mourad, B.SC.
AMBROSE, Colin Trevor
BLOOM, Keith Andrew, D.F.H.
BROADWAY, Alexander Richard William, B.SC.
BULLAR, David John, M.SC.TECH.
CHATWIN, John Arthur, D.L.C.
CHAUDHURI, Amitava, B.SC.
DAVIS, Rex Mountford, B.SC.(ENG.)
DAY, Harold Michael Chapman
DOOLAN, Patrick Thomas, B.E.
DRAPER, David Warwick, B.SC.(ENG.)
DUNSTAN, David Sydney, B.E.
EL-AKABI, Karim, B.SC.
ENSOUR, Ali Yousef, B.SC.(ENG.)
EWING, Douglas Kyles, B.SC.
FARRER, Walter, B.SC.
GATWARD, John Frederick, B.SC.(ENG.)
GILL, Austin Dell, B.SC.(ENG.)
GOLDING, Cyril, B.SC.
HACKWORTH, Capt. Timothy William, B.SC.(ENG.), R. SIGNALS
HUGHES, Robert Gordon, B.SC.
HULME, Frank
HUNTER, Ian McGregor, B.SC.
JONES, Trevor Owen
KING, Andrew Mearns, B.SC.
LEE, David Christopher Waite
LEECE, Norman Leslie, B.SC.
LOTT, Brian, B.SC.
MACKENZIE, Michael George, B.SC.
MILTON, David, DIP.TECH.(ENG.)
MORTLOCK, Roy Donald
MUDGE, John Leslie, B.SC.(ENG.)
NEAL, Geoffrey Frederick
NIBLOCK, William John, B.SC.
NORRIS, William Tobias, B.A.
PASKINS, Michael
PATEL, Lalitkumar Haribhai, B.SC.
PATON, Andrew Watts, B.SC.(ENG.)
PEGLER, John Mark, B.SC.(ENG.)
PERRIS, Brian John Frank, B.SC.
POOL, William John
PRAMANIK, Ashutosh, B.SC.
RENNIE, Robert Martin, A.R.C.S.T.
RENNISON, Donald, B.SC.(ENG.)
RISSO, Arthur James
ROWSON, Clifford Harvey, M.SC.
SALAM, Hassan Paddy Abdel, B.SC., PH.D.
SAMPSON, Richard Harold, D.L.C.
SETTLE, Lawrence, B.SC.TECH.
SUTTON, Alan John, B.SC.
SWARBRICK, John Atkinson, D.F.H.
TOWNLEY, Michael Edward
TUCK, Kenneth Richard
WEAVER, Graham George, B.SC.
WILL, Peter Milne, B.SC.(ENG.)
WINCH, Peter Ernest, DIP.TECH.(ENG.)
ZORBAS, Nicholas, B.E.

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 20TH JULY 1959

	No. of contributors	£	*s.*	*d.*
£1000 and over	8	8685	0	0
£100 to <£1000	32	7181	3	0
£5 to <£100	880	9264	19	5
£2 to <£5	2186	6024	0	0
under £2	26408	13753	9	7
		£44908	12	0

HONOURS AND DISTINCTIONS CONFERRED ON MEMBERS

THE names of the following members of The Institution were included in the list of Birthday Honours and Distinctions conferred by Her Majesty:

KNIGHTHOOD

Gamage, L. C., M.C. (*Companion*)

COMMANDER OF THE MOST EXCELLENT ORDER OF THE BRITISH EMPIRE

Brown, F. H. S., B.SC. (*Member*)
Henderson, J., M.C., B.SC. (*Member*)

OFFICER OF THE MOST EXCELLENT ORDER OF THE BRITISH EMPIRE

Barnes, D. E., G.M., B.SC. (*Associate Member*)
Best, Cmdr. K. B., M.V.O., R.N.(RET.) (*Associate Member*)
Grant, K. O. (*Member*)
Harman, R. C. (*Associate Member*)
Lawson, C. J. V. (*Member*)
Procter, W. S. (*Member*)
Skinner, W. R. T., B.SC.(ENG.) (*Member*)
Thorn, W. A. J. (*Associate Member*)
Tyson, W. R., B.SC.(ENG.) (*Member*)

MEMBER OF THE MOST EXCELLENT ORDER OF THE BRITISH EMPIRE

Allsop, C. (*Associate Member*)
Burgess, S. L. (*Member*)
Lewis, C. H. (*Associate Member*)
Mckie, A. N. (*Associate Member*)
Robins, G. W. (*Associate Member*)
Walker, N., B.SC.(ENG.) (*Associate Member*)

APPOINTMENTS AND NOMINATIONS

WIRING REGULATIONS COMMITTEE, SUB-COMMITTEE NO. 4—DISCHARGE LIGHTING

ON the nomination of the Electrical Sign Manufacturers Association the Council have appointed Mr. H. V. Vereker, B.SC.(ENG.), MEMBER, to serve on the above sub-committee in place of Mr. J. H. G. Pearce, and Mr. B. H. Pearce, B.SC.(ENG.), as Mr. Vereker's deputy.

WIRING REGULATIONS COMMITTEE, SUB-COMMITTEE NO. 7—CARAVAN INSTALLATIONS

On the nomination of the Electrical Contractors Association the Council have appointed Mr. A. Wilson to serve on the above sub-committee in place of Mr. R. E. Bristow, MEMBER.

COMMITTEE ON REGULATIONS FOR THE ELECTRICAL EQUIPMENT OF SHIPS

On the nomination of the Admiralty the Council have appointed Mr. P. Smith, B.SC., MEMBER, to serve on the above committee in place of Mr. W. C. M. Couch, C.B., C.B.E., MEMBER.

I.E.E./I.MECH.E. JOINT COMMITTEE ON MODEL FORMS OF GENERAL CONDITIONS OF CONTRACT

COMMITTEE ON MODEL FORMS OF GENERAL CONDITIONS OF CONTRACT (ELECTRICAL)

On the nomination of the Electronic Engineering Association the Council have appointed Mr. L. T. Hinton, B.SC.(ENG.), MEMBER, to serve on the above committees as the nominee of the E.E.A. following the separation of the E.E.A. from the Radio Industry Council.

COMMITTEE ON RADIO INTERFERENCE

On the nomination of the Electronic Engineering Association the Council have appointed Mr. A. H. Cooper, B.SC., to serve on the above committee as the nominee of the E.E.A. following the separation of the E.E.A. from the Radio Industry Council. (Mr. Cooper at present acts as alternate to the R.I.C. nominee, Mr. E. M. Lee, B.SC., MEMBER.)

OVERSEA ACTIVITIES COMMITTEE

The Council have appointed Mr. T. E. Goldup, C.B.E., PAST-PRESIDENT, to serve on the above committee as the representative of members in Canada in place of Sir Vincent Z. de Ferranti, M.C., PAST-PRESIDENT, who has resigned.

The Council have appointed Mr. P. J. Tyrrell, B.SC.(ENG.), ASSOCIATE MEMBER, who formerly was their Deputy Oversea Representative for Malaya and Singapore and is now in Britain, to serve on the above committee as the representative of members in the Far East in place of Mr. C. R. Webb, MEMBER, who has resigned.

OVERSEA REPRESENTATIVES

The Council have appointed Mr. B. G. Borissow, B.SC.(ENG.), MEMBER, their Oversea Representative for Argentina in place of Mr. A. C. Towers, MEMBER, who has resigned.

The Council have appointed Mr. A. J. C. Threlfall, ASSOCIATE MEMBER, their Acting Oversea Representative for the Far East while Mr. D. S. Hill, MEMBER, the Oversea Representative, is on leave.

B.S.I. SUB-COMMITTEE ELE/1/10—MARINE MOTORS AND GENERATORS

The Council have nominated Mr. H. B. Hughes, MEMBER, to serve as their representative on the above sub-committee in succession to Mr. A. Henderson, MEMBER, who has retired from the Committee on Regulations for the Electrical Equipment of Ships.

EXPLORATORY COMMITTEE ON A PROPOSED CODE OF PRACTICE ON THE PREVENTION OF CORROSION OF STEEL STRUCTURES

The Council have nominated Mr. D. P. Sayers, B.SC., MEMBER, to serve as their representative on the above committee.

TECHNICAL COMMITTEE OF LLOYD'S REGISTER OF SHIPPING

The Council have nominated Sir Archibald Gill, B.SC.(ENG.), PAST-PRESIDENT, to serve as their representative on the above committee in place of Sir George Nelson, BART., PAST-PRESIDENT, who has asked to be relieved of further service on the committee.

SOUTH SHIELDS MARINE AND TECHNICAL COLLEGE, GOVERNING BODY

The Council have nominated Mr. J. Christie, MEMBER, to serve as their representative on the above governing body.

SOUTH EAST LONDON TECHNICAL COLLEGE, ELECTRICAL ENGINEERING CONSULTATIVE COMMITTEE

The Council have nominated Mr. D. P. Sayers, B.SC., MEMBER, to serve as their representative on the above committee.

YORKSHIRE COUNCIL FOR FURTHER EDUCATION, COAL MINING ADVISORY COMMITTEE

The Council have nominated Mr. J. Mann, ASSOCIATE, to serve as their representative on the above committee.

BRISTOL COLLEGE OF TECHNOLOGY, ENGINEERING ADVISORY COMMITTEE

The Council have nominated Mr. A. G. Milne, MEMBER, to serve as their representative on the above committee.

AWARD OF PREMIUMS

THE Council have awarded the following premiums for papers read or accepted for publication during 1958:

GROUP A

The Institution Premium (value £50)
No award

The Kelvin Premium (value £25)
P. N. Butcher, PH.D. — 'Theory of three-level paramagnetic masers. 1—Quantum theory; 2—Amplification and oscillation; 3—Output noise power spectrum; 4—Noise figure'

The John Hopkinson Premium (value £25)
F. C. Winfield, M.ENG., T. W. Wilcox and G. Lyon, M.SC.(ENG.) — 'Design of 330kV transmission system for Rhodesia'

GROUP B

Electronics and Communications Section Premiums

The Duddell Premium (value £20)
A. E. Karbowiak, PH.D., B.SC.(ENG.) — 'Microwave aspects of waveguides for long-distance transmission'

The Ambrose Fleming Premium (value £15)
G. D. Monteath, B.SC. — 'Effect of the ground constants, and of an earth system, on performance of a vertical medium-wave aerial'

Premiums (value £10 each)
C. L. S. Gilford, M.SC. — 'Acoustic design of talks studios and listening rooms'

J. E. Clegg, M.SC., and T. G. Thorne, B.SC. — 'Doppler navigation'

K. W. Cattermole, B.SC. — 'Efficiency and reciprocity in pulse-amplitude modulation. 1—Principles'

H. A. H. Boot, B.SC., PH.D., H. Foster and S. A. Self, B.SC. — 'New design of high-power S-band magnetron'

D. E. L. Shorter, B.SC.(ENG.) — 'Survey of performance criteria and design considerations for high-quality monitoring loudspeakers'

L. C. Jesty, B.SC. — 'Relation between picture size, viewing distance and picture quality, with special reference to colour television and spot-wobble techniques'

D. L. Richards, B.SC.(ENG.), and J. Swaffield, PH.D., B.SC.(ENG.) — 'Assessment of speech-communication links'

J. Swaffield, PH.D., B.SC.(ENG.), and D. L. Richards, B.SC.(ENG.) — 'Rating of speech links and performance of telephone networks'

I. F. Macdiarmid and B. Phillips, B.SC.(ENG.) — 'Pulse-and-bar waveform generator for testing television links'

J. A. Lane, M.SC. — 'Transverse film bolometers for the measurement of power in rectangular waveguides'

R. G. Medhurst, B.SC., Mrs. E. M. Hicks, B.SC., and W. Grossett — 'Distortion in frequency-division-multiplex f.m. systems due to an interfering carrier'

C. G. Mayo, M.A., B.SC., and H. Page, M.SC. — 'Amplitude-modulated transmitter class-C output stage'

B. C. Angell, J. B. L. Foot, W. J. Lucas, M.SC., and G. T. Thompson, B.SC.(ENG.) — 'Propagation measurements at 3480 Mc/s over a 173-mile path'

Measurement and Control Section Premiums

The Silvanus Thompson Premium (value £20)
J. J. Hill, B.SC. — 'Precision thermo-electric wattmeter for power and audio frequencies'

The Mather Premium (value £15)
G. H. Rayner, B.A. — 'Calibration of inductors at power and audio frequencies'

Premiums (value £10 each)
E. W. Lee, B.SC., PH.D. — 'Eddy-current losses in thin ferromagnetic sheets'

E. C. Rogers, B.SC. — 'Self-extinction of gaseous discharges in cavities in dielectrics'

Prof. A. Tustin, M.SC., J. T. Allanson, M.SC., J. M. Layton, B.A., B.SC., and R. J. Jakeways, PH.D. — 'Design of systems for automatic control of the position of massive objects'

Supply Section Premiums

The Sebastian de Ferranti Premium (value £20)
W. Casson and the late F. Busemann, DR.ING. — 'Results of full-scale stability tests on the British 132kV Grid system'

The John Snell Premium (value £15)
E. P. G. Thornton and D. H. Booth, B.SC.(ENG.) — 'Design and performance of the gas-filled cable system'

Premiums (value £10 each)
P. F. Gunning — 'Standardization of control facilities for the British Grid: communications, indications and telemetering'

G. A. Burns, F. Fletcher, M.B.E., C. H. Chambers and P. F. Gunning — 'Development of communication, indication and telemetering equipment for the British Grid'

J. H. Walker, M.SC., PH.D. — 'Slot ripples in alternator e.m.f. waves'

'Operating characteristics of salient-pole machines'

'Voltage excitation characteristics of synchronous machines'

J. H. Walker, M.SC., PH.D., and N. Kerruish, M.A. — 'Parallel operation of two synchronous machines'

'Design of fractional-slot windings'

Utilization Section Premiums

The Crompton Premium (value £20)
P. McKearney, O.B.E., L. S. Drake and E. G. Mallalieu, B.SC. — 'Development of variable-speed high-power drives for large wind tunnels'

'Variable-frequency power installation for large wind-tunnel drives'

The Swan Premium (value £15)
C. M. Cock — '*Deltic* locomotive'

Premium (value £10)

B. C. Robinson, M.SC., PH.D., and A. I. Winder	'Supply-voltage and current variations produced by a 60-ton 3-phase electric arc furnace'

Non-Section Premiums

The Ayrton Premium (value £20)
No award

The Llewellyn B. Atkinson Premium (value £15)
No award

Premium (value £10)

P. Hammond, M.A.	'Electromagnetic energy transfer'

GROUP C

The Blumlein–Browne–Willans Premium (value £20)

D. Gabor, DR.ING., F.R.S., P. R. Stuart, PH.D., and P. G. Kalman, PH.D.	'New cathode-ray tube for monochrome and colour television'

The Frank Gill Premium (value £15)
No award

The Heaviside Premium (value £15)

Z. Godziński	'Use of equivalent secondary sources in the theory of ground-wave propagation over an inhomogeneous earth'
	'Comparison of Millington's method and the equivalent-numerical-distance method with the theory of ground-wave propagation over an inhomogeneous earth'

Oversea Premiums

For senior members (value £15)
No award

For Students and Graduates under 28 years of age (value £10)
No award

Graduate and Student Premiums

Premiums (value £10 each)		*Section*
H. E. Coles, B.ENG.	'Application of electronics to jet-engine control'	London
G. K. Creighton, B.SC.(ENG.), and W. M. Somerville	'Novel methods of speed control applied to standard 3-phase squirrel-cage induction motor'	Bristol
D. Marshall	'Protection of 132kV transmission systems'	North Midland
Premiums (value £5 each)		
J. A. Chandler, B.SC.(ENG.)	'Junction transistors and their applications'	Rugby
J. A. Denham, B.SC.(ENG.)	'Insulation failure'	North-Eastern
A. P. Foster, B.SC.	'Coal mining and electricity'	Mersey and North Wales
J. J. Hunter	'Electronics in engineering research'	South-West Scotland
R. B. Larkinson, M.A.	'Use of analogue computers in analysis of rolling-mill control systems'	North Staffordshire
W. A. McCartney	'Electro-mechanical transducers'	Northern Ireland
R. J. Meredith, B.SC.	'Preventing crane collisions electronically'	Rugby
Letters of Commendation		
R. B. Coates, B.SC.	'Control of nuclear reactors'	North-Eastern
B. G. Cryer	'Distribution design'	Sheffield
J. A. Darke, B.SC.(ENG.)	'Nuclear power-reactor control'	Rugby
R. M. Epps	'Preset screwdown control in steel rolling mills'	Tees-Side
E. F. F. Gillespie, M.ENG.	'Voltage stabilizers'	Sheffield
M. H. Kendon, B.SC.(ENG.)	'Some aspects of thermo-nuclear power'	East Midland
P. J. Lawrenson, M.SC.	'Linear electrical machines'	North-Western
A. St. John MacKellar, B.SC.	'Nuclear power stations'	North-Eastern
D. K. MacLennan, B.SC.	'Analogies'	South-East Scotland
A. I. Taverner, B.SC.	'Heat transfer in cooling of electrical machines'	North Staffordshire

LONG-DISTANCE TRANSMISSION BY WAVEGUIDE

IT is hoped that papers and discussions at the recent Convention on Long-distance transmission by waveguide will be published shortly in a Supplement (No. 13) to Part B of the *Proceedings*. This supplement—with its contents and index pages and in a semi-stiff cover—will be complete in a single issue. The prices (post-free) are £1 7s. 6d. to members of The Institution and £2 15s. to non-members.

Copies may be obtained on application to the Secretary.

MEMBERS TRAVELLING TO AND FROM THE UNITED KINGDOM

MEMBERS visiting or taking up residence in the areas of any of the Oversea Branches, Oversea Committees or Joint Groups which are listed on pp. 497 and 498 are invited to apply to the Secretary of The Institution for a letter of introduction to the appropriate Honorary Secretary.

The Secretary will be obliged if members coming home from oversea will inform him of their addresses in this country even if they do not desire a change of address to be recorded in the Institution register. This will enable him to send them information about the various meetings etc. of The Institution and its Local Centres and when occasion arises to put them in touch with other members.

The Secretary will be glad if members from oversea who are able to visit the Institution premises will call on him.

STUDENTS' QUARTERLY JOURNAL

AN interesting survey of the use of electricity in aircraft by B. L. Perry is the first article in the June 1959 number of the *Students' Quarterly Journal*. The next article by F. L. Fielding also has an aeronautical flavour in dealing with Tacan, an air navigational aid. Other articles are 'Electricity in Western Australia' by R. G. Harvey; 'Standard frequency a.c. traction' by W. D. Hodgson; 'Microwave transmission' by J. A. Staniforth; 'Instrumentation and process control' by D. W. Hodkinson; and 'Transistors in switching circuits' by M. Paskins.

In addition to book reviews and Section news there is published an abstract of the examiners' report on the June and November 1958 Part III Institution Examinations. The index to Vols. 28 and 29 completes this 64-page issue.

CONTROL ENGINEERING

ONE-YEAR POSTGRADUATE COURSE

THE College of Aeronautics announce that they have made arrangements for a one-year course in control engineering to begin on the 5th October 1959. The purpose of the course is to instruct trained engineers and scientists in the techniques most commonly used in the design of control systems.

The level of instruction will be appropriate to men holding good honours degrees. The course will be intensive, and electrical engineers and physicists will profit most. Practical experience in a suitable field will be a considerable advantage but is not essential. Further information and forms of application for the course may be obtained from the Warden, the College of Aeronautics, Cranfield, Bletchley, Bucks.

COMMUNICATION CONGRESS IN GENOA

THE 7th International Communication Congress takes place in Genoa from the 5th to 12th October 1959. The divisions of the congress are: space communications, air communications, telecommunications, land communications and sea communications. Among the papers to be presented in the telecommunications session are 'Subscriber trunk dialling' by Brig. Sir Lionel Harris and 'Future transmission systems—Waveguides for long range' by Mr. Thomas Scott.

Further information may be obtained from the Civico Istituto Colombiano, Palazzo Tursi, Genoa, to which completed application forms must be sent by the 20th September 1959.

Special General Meeting, 18th August 1959

AT a Special General Meeting of Corporate members only at the Institution of Civil Engineers on the 18th August 1959, at which 542 such members were present, a Resolution of the Council proposing increases in Annual Subscriptions was offered for confirmation.

After a discussion contributed to by 13 speakers a show of hands was taken and 369 voted in favour and 139 against. A poll was then demanded by three members personally present, and this on the direction of the President as Chairman of the meeting was taken forthwith.

The result of the poll was:

For confirmation of the Council's Resolution **4701** votes.
(personal 302, by proxy 4399)

Against confirmation of the Council's Resolution **736** votes.
(personal 83, by proxy 653)

Details of the increases which will become operative on the 1st January 1960 will be published in the next issue of the *Journal*.

In the course of the meeting the President stated that he had decided to recommend to the Council the setting up of a special committee to consider the many proposals and comments which had been put forward by members, not only at the Special General Meetings of 9th April, 25th June and 18th August 1959 but also in the extensive correspondence that had been received.

He was confident that the Council would take this action and that with the assistance of the successive reports of this committee the Council would be able to report to members during the coming session on the actions they were taking.

Note: In view of the President's statement and of current printing difficulties the customary fuller reports of the three Special General Meetings have been omitted.

British Nuclear Energy Conference

DETAILS of a forthcoming meeting of the British Nuclear Energy Conference are given below. Papers and discussions on the applications of nuclear energy and ancillary subjects are published in the quarterly *Journal of the British Nuclear Energy Conference*. The annual subscription payable by members of The Institution who wish to receive the *Journal of the B.N.E.C.* regularly is 30s. post-free. Single copies are available at 7s. 6d. each

1959

OCTOBER 7 *Wednesday* (4.45 p.m.)

Sponsoring society and place of meeting: The Institution of Naval Architects, 10 Upper Belgrave Street, London S.W.1.

NUCLEAR-POWERED DRY CARGO SHIPS E. C. B. Corlett and E. P. Hawthorne

Contents of the current issues of the *Proceedings*

The date in italics is that of the Journal review, special article, or synopsis. Where given, the date in CAPITALS is the month in which a paper or monograph was published individually

PART A. POWER ENGINEERING (AUGUST 1959)

K. W. WARDROP, B.SC.(ENG.). PAPER 2890 S **Analogue computer to evaluate the cost of changes in power on a power system** *August 1959*

D. W. FRY, M.SC. PAPER 2903, APRIL 1959 **Review of work towards nuclear energy from controlled thermonuclear reaction** *August 1959*

E. JACKS. PAPER 2805 U, JANUARY 1959 **Discrimination between h.r.c. fuses** *May 1959*

P. E. SECKER, B.SC.(ENG.), AND A. E. GUILE, PH.D., B.SC.(ENG.). PAPER 3044 S **Arc movement in a transverse magnetic field at atmospheric pressure** *August 1959*

D. B. MCKENZIE, B.SC. PAPER 2912 U **Electrical material and components for aircraft power equipment operating at high temperatures** *September 1959*

C. S. JHA, B.SC., AND A. R. DANIELS, B.SC. PAPER 3049 U **Starting of single-phase induction motors having asymmetrical stator windings in quadrature** *August 1959*

Communicated discussion on **Performance calculations of the capacitor motor using the transformer analogue analyser**

Communicated discussion on **Generalized locus diagram for induction motors**

PART B. ELECTRONIC AND COMMUNICATION ENGINEERING (JULY 1959)

D. A. BARRON, M.SC. PAPER 2795 E, NOVEMBER 1958 **Subscriber trunk dialling** *April 1959*

Communicated discussion on **Capacitance between electrodes in the presence of space charges**

F. E. WILLIAMS, M.SC.(ENG.), AND F. A. WILSON. PAPER 2867 E, MARCH 1959 **Design of an automatic sensitivity control for a new subscriber's telephone set—the British Post Office 700-type telephone** *June 1959*

Communicated discussion on **Transistor active filters using twin-T rejection networks**

A. H. W. BECK, B.SC.(ENG.). PAPER 2750 E, NOVEMBER 1958 **High-current-density thermionic emitters: a survey** *May 1959*

F. J. HYDE, M.SC. PAPER 2855 E **Investigation of the dependence of the current gain of a plane-alloy-junction transistor on emitter current and frequency** *May 1959*

F. J. HYDE, M.SC. PAPER 2856 E **Investigation of the current gain of a drift transistor at frequencies up to 105 Mc/s** *May 1959*

F. J. HYDE, M.SC. PAPER 2857 E **High-frequency power gain of the drift transistor** *May 1959*

E. L. C. WHITE, M.A., PH.D. PAPER 2946 E **Frequency modulator for broadcasting transmitters utilizing over-all negative feedback** *June 1959*

P. GRANEAU, B.SC.(ENG.). PAPER 2945 M **Effect of sample movement in fault detection using eddy currents** *June 1959*

P. C. BUTSON, M.SC., AND G. T. THOMPSON, B.SC.(ENG.). PAPER 2874 E **Effect of flanges on the radiation patterns of waveguide and sectoral horns** *April 1959*

K. P. SHARMA, M.SC., PH.D. PAPER 2881 E **Estimation of the reactance of a loss-free surface supporting surface waves** *August 1959*

H. H. SCHOLEFIELD, PH.D., H. H. H. GREEN, B.SC.(ENG.), AND R. E. GOSSETT. PAPER 2996 E **Manufacture of waveguide parts by investment casting from frozen-mercury patterns** *August 1959*

Communicated discussion on **Novel high-accuracy circuit for the measurement of impedance in the a.f., r.f. and v.h.f. ranges**

PART C. MONOGRAPHS (MARCH 1959)

See the Journal for March 1959, p. 192

BULLETIN OF THE SECTIONS

UTILIZATION

Lighting and architecture

THE lecture given at Savoy Place on the 7th May 1959 by Mr. J. M. Waldram on 'Lighting and architecture' was profusely illustrated with colour slides and demonstration fittings and traced the development of the art of lighting from the days of the candle and the oil lamp to the present.

Mr. Waldram showed how the electric lamp was first regarded purely and simply as a replacement for the candle and oil lamp (as indeed it often is today) without realization of its inherent superiority as a source of light.

The practice of mounting lamps in accessible pendant fittings arose from the original necessity for lighting the candle with a wax taper and could only now be justified in special circumstances where an intimate form of lighting or a special decorative effect was desired. Such fittings formed part of the furniture of a room rather than of its architecture, and too often they were chosen with an eye to daylight appearance rather than for any intrinsic illuminating effect.

He discussed indirect lighting and its often unfortunate effects and the so-called 'architectural lighting', which could give quite undue and undesirable emphasis to some particular feature of the structure, again with little regard to the over-all illuminating effect. He showed how the use of illuminated false ceilings tended to distract attention from the normal objects of regard unless special steps were taken to reduce the ceiling brightness and to introduce some form of directional lighting which gave the required modelling effect. Alternative ways of achieving these ends were discussed in detail and many illustrations given of installations of outstanding merit.

'Seeing' the light

In conclusion Mr. Waldram made a very strong plea for an entirely new approach to design in the visual field, suggesting that it should begin with a conception of the appearance of the lighted interior, perhaps in the form of a sketch. The architect's conception could be interpreted quantitatively as regards the distribution and level of brightness and the emphasis, the decorations and the modelling.

By simple calculation the adaptation effects and reflection and inter-reflection factors could be allowed for, and the direct light to be provided by the lighting installation on each of the principal surfaces could be assessed. The directions from which the light should come would be indicated by considerations of modelling; and, where decorative equipment or luminous features were to be used, the extent to which concealed equipment should support them could be readily ascertained.

Some beautiful colour slides of the interior lighting of Gloucester Cathedral showed how effective could be the application of this technique. A good lighting installation, Mr. Waldram emphasized, could only be the result of a happy partnership between the architect, the lighting engineer and the installation engineer. R. A. M.

MEASUREMENT AND CONTROL

Instrument maintenance

THE informal discussion which was held on the 21st April 1959 at Savoy Place was marked by the high proportion of the audience participating in the discussion. The subject, 'The problem of maintenance of electronic equipment in the process industries', is, of course, one on which many members hold strong opinions and of which some have had lively experiences.

Dr. G. Morris gave a remarkably full account from his wide practical knowledge of designing for reliability of the plant. He pointed out that the cost of a breakdown increases rapidly with stoppage time, quoting as an example £10 for one hour, £70 for 3 hours and £560 for 6 hours. He favoured printed circuits, colour codes, and neat lay-out and showed some examples made by his own firm which have given nine years of trouble-free service. He said that a guarantee of, say, 1000 operating hours only meant something if the duty cycle was also stated: it could mean anything between four years and six weeks.

Dr. Morris stressed the need for adequate instructions, designed for various levels of personnel. His estimate that a 20% increase in capital cost leads to a 30% increase in reliability was, however, challenged by several speakers who felt that it was quite easy to double and even treble the cost of commercial equipment designed for reliability.

Mr. N. T. C. McAffer of the U.K.A.E.A. spoke about administrative and statistical aspects of fault investigations at Risley. He described their standard fault-card, with which the operational efficiency of the Authority's plants could be investigated and 'safe' failures distinguished from 'unsafe' ones.

Hoarding of spares

Another disputed point leading to lively discussion was the use of built-in marginal-test facilities versus breakdown repairs only. Mr. R. J. Redding advised against routine overhaul, which, in his experience, led to unreliable operation. He also warned against keeping large stocks of spare components, especially those which had a shelf life comparable to the service life of the instrument, such as vacuum devices or electrolytic condensers.

Another point raised was the future availability of spares.

While approximately 10 years was acceptable, it was said that in one official tender a guarantee of availability for 25 years was given, which would probably be far in excess of the lifetime of the instrument itself.

Mr. J. M. Keating thought that electronic control systems are at present less reliable than pneumatic ones but added that the position is improving. He also said that miniaturization could be accepted in wall-mounted panels, where it enables the operator to survey a larger number of instruments, but not for console-type controls.

Mr. R. C. Vincent made the point that transistorized convertors are more reliable than choppers and other mechanical devices. He also stressed the need for feeding service experience to instrument makers and complained of the apparent lack of interest on the part of some.

Dr. A. Nemet said that the cost of well designed instruments sometimes causes less reliable ones to be bought, simply because when buying it is less easy to assess reliability than to compare prices. He also raised the question of flame-proofing versus intrinsic safety, which was answered in favour of the latter by several speakers including Dr. Morris.

Training of the maintenance staff by the instrument makers was generally agreed to be necessary, as well as interchangeable unit construction of electronic equipment.

Instrument hygiene

Mr. P. A. Cartmell favoured over-all tests, but although relatively easy in some nuclear measurements this procedure may be complicated in chemical plants. He also mentioned decontamination of nuclear electronic equipment: instruments exposed to such hazards should have a smooth exterior which can be easily cleaned, the ideal solution being to operate an instrument inside a polythene bag. This would normally lead to overheating, but transistorized units hold out some hope of achieving this ideal.

The Chairman, Mr. J. K. Webb, mentioned the repeaters of submarine cable as examples of reliably designed electronic equipment and drew attention to the wrapped-joint technique, which, compared with soldered joints, has led to considerable improvement in the reliability of computer manufacture.

Long after Mr. Webb had closed the meeting, the audience were to be found in small groups discussing their experiences.

A. N.

Summer in the Thames Valley

THE centre of attraction for the Summer Visit on the 23rd May this year was the A.E.I. research laboratory at Aldermaston, and it was a beautiful May morning when the party gathered at Reading.

The ladies went off on a coach trip through the Thames Valley seen at its very best. After coffee at Henley they visited Hughenden Manor, the home of Disraeli, at High Wycombe, which houses a small museum and a collection of portraits of historical interest. From there they continued to Marlow for lunch with the rest of the party.

Aldermaston brings forth recent memories of public turbulence regarding the Atomic Weapons Research Establishment, but the neighbouring A.E.I. laboratory is a quiet home of science led by Dr. T. E. Allibone, who welcomed the party and whose willing co-operation made the visit possible.

The research work in hand was so diverse in nature that there was something to interest everyone, even if some felt a little at sea among nuclear physicists. For those who study the minutest detail there was an illustrated description of the deformation of metals, not in large lumps but one crystal at a time. Another facet of mechanical engineering dealt with the wear of metals at rubbing contacts, and an ingenious machine designed and built at the laboratory rubbed the faces together and measured the electrical resistance and capacitance between the surfaces.

Well tamed sparks

Some very well tamed long sparks were produced in the high-voltage laboratory, followed, by way of contrast, by ordinary, wild, long sparks. The study of the breakdown of the gap is greatly helped by high-speed photography, and a special camera with a high-speed mirror has been developed in the laboratory.

SUPPLY

Turning to nuclear physics, the large Van de Graaff generator is an impressive machine, as tall as a house and capable of providing 4 MeV. Proton and deuteron beams run vertically down the main tube and are cunningly deflected into the horizontal plane for use in irradiating various targets. The speed of the particles is measured by the electrostatic energy required to flatten out their dive. The particle yields and energies are determined with a large magnetic spectograph, and a special spectrometer measures the yields and energies of γ-rays. Incidentally, no smoking, eating or drinking is allowed in this building, and yet the laboratory assistants are living humans.

Attempts to produce a controlled thermonuclear reaction by the fusion of heavy hydrogen (deuterium) are being

Social subcommittee meeting in progress?

Mr. E. Mills, Mr. F. C. Walmsley, Mr. D. P. Sayers and Dr. J. R. Mortlock, Chairman-Elect

SUPPLY (continued)

pursued by means of the device Sceptre III. During the visit this was under reconstruction, and the interior of the toroid could be seen. Very large banks of condensers provide the surge of power to the toroidal windings which heat the gas and hold it away from the walls. Again, colour-photographic studies of the gas provide much useful information.

Lunch was generously provided by the Southern Electricity Board at the Compleat Angler Hotel at Marlow, a happy choice on such a delightful day. The brevity and wit of the speech by the Board's Chairman, Mr. R. R. B. Brown, and our Chairman's reply fitted the occasion admirably.

Safe clearance

After lunch the party boarded a steamer for a short cruise down river to Cookham. A few seconds after starting only rapid ducking of heads saved a sudden shrinkage in the membership of the Section when passing under Marlow Bridge with an inch or so to spare. The safe survival made one wonder if the enormous clearance provided beneath overhead lines is really necessary. The cruise was further enlivened by a large number of dinghies sailing in a stiff breeze off Bourne End, with the inevitable capsize of one of them.

Tea was taken on board, and on return the party broke up at Marlow all too soon, to enable those returning to London to catch their train. W. J. N.

Epilogue

On a beautiful day, on a morning in May
The Supply Section reached Aldermaston.
We all had an urge to inspect the research,
And found that its range is a vast 'n.

In a kind of a dream we were shown a machine
(The idea is to split up deuterium);
It's attained, if you please, several million degrees,
And I felt on the verge of delirium.

And when this was ended, to Marlow we wended
For lunch with the kind Southern Board,
At the Angler Compleat we were almost replete
When our steamer we scrambled aboard.

In a stiffening breeze we just sat down at ease,
And watched little yachts gaily racing.
Then homeward were bound, with both feet on the ground,
The whole day had been mightily bracing.

Shylock

Station auxiliaries

A well attended meeting, with Mr. D. P. Sayers in the chair, was held at Savoy Place on the 22nd April 1959 to hear and discuss Mr. D. A. Dewison's paper on 'Electrical supplies to power-station auxiliaries' (reviewed on p. 460). Owing to 'interior alterations and decorations' elsewhere, the meeting was held in the Institution Library, and the resulting touch of informality appeared to have a stimulating effect on the audience.

Mr. Dewison described some possible arrangements for auxiliary supplies in coal-fired stations having plant installed on the unit system and emphasized the superiority of the unit-transformer/station-transformer scheme from the economic viewpoint. He went on to discuss variants of the basic scheme and surveyed the various auxiliaries in a modern station, with special emphasis on boiler-feed pumps, which form the largest single item of the auxiliary load.

'Caught' at the Compleat Angler are the President, Mr. S. E. Goodall, Mrs. Sayers, Mrs. Goodall, Mr. D. P. Sayers, Chairman of the Supply Section, and Mr. R. R. B. Brown, Chairman of the Southern Electricity Board

While the smaller motors require a 415-volt supply, a real problem exists in determining the supply to the larger units, and the relative merits of 3·3, 6·6 and even 11 kV need careful evaluation.

For the future Mr. Dewison visualized boiler-feed pumps driven from the main shaft of the turbogenerator or by a separate steam turbine in the case of coal-fired stations having units of the largest outputs. Nuclear stations might require special consideration for coolant circulation and adequate standby supplies for vital circuits but otherwise raised no special problems.

Opening the discussion Prof. R. O. Kapp remarked that most of the efforts of the design, construction and operating staff of a station were expended on the auxiliaries and that the main turbogenerator unit took a very minor place.

The costing of electrical energy had been raised to a much finer art than that of any other commodity, and it was to this that we owed the relatively low cost of supplied electricity today. As a result operators were continually looking for small gains in efficiency, and Prof. Kapp welcomed the author's critical survey of auxiliary-supply arrangements. Reliability could only be assessed from experience, and one really wanted to know what would happen if there were no standby; but this was an extremely difficult statistic to acquire.

Mr. C. Bottrell pointed out that the unit system could not be applied completely to nuclear stations, owing to the multiplicity of boilers and sets per reactor.

Mr. D. E. Bird was concerned with the relative merits of various auxiliary-supply lay-outs and pleaded for a 3-voltage system for certain applications. He also referred to the tendency of the operators to make preferential use of the boiler-feed pump connected to the unit transformer and suggested that it should be possible for both pumps to be wired up to this source.

Mr. W. N. Waggott suggested a simple scheme with a main switch between the generator and its two associated transformers (main and unit) which enabled the station transformer to be dispensed with. This had many advantages for smaller stations though it was admittedly impracticable for large units.

Mr. F. J. Hutchinson advanced some novel concepts of station design procedure, suggesting early consideration of cable problems. He went on to discuss faults on motor terminal boxes and made a strong plea for a review of terminal-box design, adding that low-voltage motors might have advantages in borderline cases.

Mr. A. Abbott emphasized the advantages of air-break gear in savings on civil-engineering work, and Mr. Myers gave some interesting statistics on auxiliary loads as a percentage of station output in varying conditions.

A brisk discussion ensued covering all aspects of auxiliary installations, with emphasis on switchgear and boiler-feed pumps. It was quite evident that finality has not yet been attained by any means and that the protagonists of station and of area-board supplies for emergencies remain unmoved in their beliefs.

Mr. Dewison, in reply, dealt ably with the various points which had been raised and pointed out that in many cases two schools of thought existed and local circumstances often determined the practice adopted. He endorsed the advantages of air-break switchgear and added that even without the resulting savings in civil-engineering work there would normally be economies. He concluded with a provocative statement that distribution engineers do not realize the problems of power engineers.

In moving a vote of thanks to the author the Chairman emphasized the usefulness and general interest of the points brought out in the paper and discussion and expressed the thanks of the meeting to all who had contributed.

W. J. C.

The Chairman's remarks

As Chairman of the Section but one who is not closely engaged in the transistor field, I was able to leave the detailed planning of the Transistor Convention to the experts and to enjoy the experience of viewing the proceedings from a privileged position. The sight from the dais of the Warwick Hall at the opening session was most inspiring, and it was obvious that, with the President in the chair, Lord Hailsham and the Nobel Prize-winners, we were off to a flying start. Certainly at the convention lunch which followed there was a spirit of optimism which gave us a feeling that we were making history.

Meanwhile the associated exhibition was already attracting many favourable comments and a large number of visitors. The daily totals of visitors proved that the concept of supporting the convention by a full-scale scientific exhibition was abundantly justified.

It was clear from the attendance at the technical sessions that the importance of the convention as a forum for an international exchange of ideas and information had been fully established. When I took the chair at the last specialist session I found that the enthusiasm had been sustained to the end, and as the delegates streamed out of the Warwick and Richmond Halls they saw that the exhibition was already fast disappearing.

All was over bar the shouting, which was done with due decorum at the dinner later in the evening. It was indeed a privilege to receive well over 400 guests and to be seated between the President and Dr. Shockley, who respectively proposed and replied to the toast to the visitors. Full honours were accorded to all who had any part, large or small, in the planning and running of the convention.

I count myself fortunate that such an event should have taken place in my year of office, especially as it followed two smaller conventions sponsored by the Section earlier in the session. The International convention on Transistors and associated semiconductor devices was a great experiment, and much will be learnt from it with regard to the pattern of future Institution conventions.

G. MILLINGTON

ELECTRONICS AND COMMUNICATIONS

Commercial television

At a meeting held at Savoy Place on the 24th April 1959 a lecture was given by Messrs. T. C. Macnamara and B. Marsden on the 'Engineering aspects of commercial television programme presentation'. Mr. G. Millington was in the chair.

Mr. Macnamara stressed the considerable difference between the requirements of commercial television broadcasting and non-commercial, or licence-maintained, broadcasting. He thought that the biggest single factor was in the method of obtaining revenue. With commercial broadcasting, revenue is closely and directly linked to the programme presentation and a portion to the presentation of commercial advertisements, while in licence-maintained broadcasting in this country this relationship is comparatively remote. He also suggested that the distribution of a single programme over one network, except for regional 'opt-outs', was relatively simple, and the programme-timing problem was not so acute.

Timed by TIM

He examined the problems facing commercial television, where there is no comparable single network but where arrangements have to be made for the interchange of programmes between the ever-growing number of programme contractors, at the same time ensuring that the all-important commercial advertisements are accurately inserted into predetermined commercial breaks by the individual contractors.

This complicated operation calls for extremely accurate timing throughout, split-second switching and close co-operation between all concerned. Accurate time indication has been achieved by the adoption of TIM as the standard for studios and outside-broadcast units, and where a telephone feed line is not available a local transistorized crystal-controlled clock accurate to within 1 part in 10^5 is used.

With filmed programmes, which are recorded at 24 film-frames/sec, accurate timing is achieved by reproducing them at the same speed instead of at the television picture-repetition rate of 25 per second. A vidicon teleciné is used for this, and

application-bar problems are overcome by introducing a compensating signal derived from the difference between the television and film frame frequencies.

'Clean feed'

Mr. Marsden covered the more technical aspects of master control and switching. He emphasized that when a programme contractor is sending a programme to other regions in addition to his local transmitter, care has to be taken that only the programme is sent to the network and that all the commercials for radiation by his local transmitter are omitted. This 'clean feed' of programme is achieved by means of a master selection switching system in the master control room. Some studio centres are planning automation, particularly during commercial breaks, when up to six or eight picture and sound changes are necessary with split-second timing.

Genlocking equipment, which locks the video synchronizing signals generated at two separate and usually remote sources, is extensively used to ensure a smooth presentation of material originating from different parts of the country and for the quick-fire insertion of commercials. Frequently an incoming programme from a remote source was not available to the recipient for more than 8sec before the actual time of transmission, but automatic genlocking equipment can be brought into action by a single switch operation. Mr. Marsden described how automatic genlocking could be used for mixing studio and film programmes and commercials with programmes on video tape.

Video-tape recording

Finally, Mr. Macnamara referred to the importance of the relatively new process of video-tape recording. He stressed the advantages of video tape over film telerecording as regards both time factor and technical quality. In addition, a much better studio-usage factor is obtained, since programmes can be recorded when studios might otherwise be lying idle, and the number of studios required can thus be reduced. He thought, however, that film, and particularly 16mm film, will continue to play a very large part in the exchange of television programmes for a considerable time.

The lecture ended in a lighter vein with a short entertaining film showing what might happen in the master control room of one of the well known programme contractors.

Problems of a single network

Opening the discussion Mr. H. W. Baker agreed that non-commercial television programme presentation in this country was made simpler by the fact that programmes from whatever source were normally received in a central control room in London and distributed over one national network to the various transmitters. However, complex operations were frequent with regional 'opt-outs' and certain topical programmes; the latter involved contributions from many sources, including local and regional studios, teleciné, and outside broadcast units, and comprehensive switching and cueing facilities and accurate time indication were essential. The latter had particular importance when certain national programmes were fed to the I.T.A. network. He asked whether completely satisfactory synchronization was achieved when, for example, studio cameras were mixed with video-tape programmes. Mr. Marsden assured him that this was so.

Mr. D. R. Morse referred to the teleciné reproduction of film at 24 frames/sec. He wondered if the method described to eliminate the application bar was completely successful and foresaw difficulties if the television signal was unlocked from the electricity supply mains in the future. Although considerable progress has been made in film telerecording, Mr. Morse felt that with the superior quality obtainable from video tape the use of film for direct telerecording would gradually diminish, except for international programme exchange. If international television standards were adopted, however, one could foresee the exchange of programmes on tape.

Dr. R. C. G. Williams asked how the cost of network circuit and facilities was apportioned when, for example, a programme contractor in Scotland takes a programme from another in Birmingham. Mr. Macnamara replied that the network was a permanent facility and the cost was shared by the programme contractors: a charge was made for the exported programme.

Mr. G. Millington, in thanking Messrs. Macnamara and Marsden for their interesting lecture on this relatively novel subject, was fully supported by the audience. H. W. B.

News from the Centres

NORTH STAFFORDSHIRE SUB-CENTRE

The cultured engineer

It is some time since the Sub-Centre held a discussion meeting, so arrangements for the 16th February 1959 at Stafford were in the nature of an experiment, which proved to be very successful. We also had the honour of a visit by a Vice-President, Mr. A. H. Mumford, who said he found it a pleasant duty to visit the Centres and Sub-Centres and commented on the enthusiasm he found in so many. The atmosphere was quite different from that in London because closer contact could be made with the smaller audiences.

After thanking Mr. Mumford, the Chairman, Mr. R. W. Palmer, invited Dr. K. R. Sturley to open the discussion on 'What is a cultured engineer?'. After quoting definitions from many authorities, Dr. Sturley suggested that the marks of a cultured man could be considered under these headings:

Refinement of manner
Acquaintance with the past
Ability to manipulate abstract ideas
Interest in expressions of beauty
Ability to communicate.

He discussed each requirement in turn and indicated the extent to which normal training and experience of an engineer would contribute and how the deficiencies might be made up.

Prof. F. A. Vick followed up this theme by stressing the difference between training and a broadly based education. He emphasized the importance of the close relation between culture and moral standards, the effects of the home background, and the value of the communal life of the university.

A lively discussion followed to which nine members contributed. Reference was freely made to Dr. Sturley's five headings. Some thought the standard was too high, while one speaker said that a form of culture could be found in peasants and that religion was a very valuable form of culture. Another suggested that a qualified engineer must already have at least four of the items and might lack only knowledge of the past. He thought the mind should pursue some object for its own sake and there should be a sense of vocation in one's work.

Another definition suggested was 'one who is able to enjoy the leisure which he helps to attain for others'. In a brief reply Dr. Sturley agreed that tolerance is most important and that religion is the backbone of Western culture.

A vote of thanks was proposed by Mr. M. R. Ward, who said the meeting had proved to be very interesting and quite out of the usual run. He thanked Dr. Sturley and Prof. Vick for their able, thought-provoking and inspiring contributions.

Graduate papers

A joint meeting with the Graduate and Student Section was held at Stafford on the 16th March 1959, when three short papers were presented by members of that Section. The Chairman, in introducing the three authors, said how pleasurable these annual joint meetings had now become.

Mr. A. W. Simpson read his paper entitled 'Basic thoughts on power-transistor design', which briefly but comprehensively surveyed the development of the geometry of the junction transistor. An interesting discussion, opened by Mr. R. J. Polding, ranged from size limitations to the development in America of a *p-n-p-n* transistor capable of controlling quite heavy currents.

Mr. P. J. Walker's paper on 'The digital computer Deuce' was followed immediately by Mr. W. Tullock's on 'Applications of special-purpose computers'. The combined discussion on these two papers was opened by Mr. M. T. Challenger and Mr. A. Davies and covered such diverse subjects as the comparative cost of the various types of storage, how the magnetic storage drum is kept in synchronism and the reliability of electro-mechanical relays in computer application.

A vote of thanks was proposed by Mr. A. P. Baines, who said that these combined meetings had developed into really interesting and informative evenings which were looked forward to by members of the senior section just as much as by the Graduates and Students.

Introducing Grace

On the 16th April 1959 a joint meeting with the Stone/Stoke Centre of the Institution of Post Office Electrical Engineers was held at Stone. Mr. H. R. Harbottle, chairman of that centre, welcomed the Sub-Centre to the Central Training School but was not sure whether he could include our Chairman, Mr. R. W. Palmer, who was already his Vice-Chairman and Principal of the School. When this had been settled satisfactorily, Mr. Palmer took the chair for the remainder of the meeting.

He expressed his pleasure in finding that seven Institution prizes had been awarded to students in this Sub-Centre—Messrs. E. K. Davey, C. A. Forster, F. D. Shaw, W. Abbott, K. G. E. Bowler, R. M. Hancock and E. T. Powner.

In presenting his paper on 'Subscriber trunk dialling', reviewed in the April 1959 *Journal*, p. 236, Mr. D. A. Barron introduced his hearers to Grace (group routing and charging equipment), and this lady's name continually cropped up during the evening. Opening the discussion, which was joined by about a dozen members, Mr. W. T. Warnock spoke of further developments which might be considered and also referred to the training of maintenance men, suggesting that the present training on electro-mechanical equipment does not lead on to maintenance of electronic equipment, which is quite different.

In reply Mr. Barron said the men at Bristol had adapted themselves very quickly to the first installation of this equipment. They were helped very much by the built-in testing and fault-location devices.

Mr. J. E. Boul proposed a vote of thanks to the author for a very interesting and stimulating talk and complimented him on successfully resisting the temptation to use jargon that many would not understand. He had heard a lot about Grace during the evening but no one had suggested introducing Grace to Ernie—which he thought might be quite remunerative. L. G.

SCOTTISH CENTRE

Pitlochry again

In perfect weather the Spring Meeting was held at Pitlochry during the week-end of the 23rd–24th May 1959. The Hutcheson–Winning Golf Trophy was this year won by Andrew Menzies of Elgin, who beat, by one stroke, J. K. Moffat of Edinburgh. For the Saturday afternoon the party divided, the men (with one brave lady) visiting Port-na-Craig House, the control centre for the Hydro-Electric Board network, and the ladies (with a few brave men) having a particularly enjoyable excursion to Blair Castle.

Both parties were entertained to tea at Clunie power station, where they were welcomed by Mr. A. A. Fulton, general manager of the North of Scotland Hydro-Electric Board, and Mrs. Fulton; Mr. R. J. Rennie, Chairman of the Centre, cordially thanked the Board and Mr. and Mrs. Fulton.

The play on Saturday evening at Scotland's 'theatre in the hills' was 'The wonder' by Susannah Centlivre, a Restoration comedy made famous by David Garrick and thought by those present to be one of the best shows seen by members and guests on these yearly visits. Sunday was devoted to the usual enjoyable social activities; alarm and despondency, however, was caused in the late evening by one of the bachelor members, who, in giving a 'lift' to three lady guests for the short journey from the salmon ladder to the hotel, was apparently smitten with a sudden urge to take them on a much longer expedition to see 'Queen's view' by moonlight.

The annual sugar-coated pill

At the Annual General Meeting, held in Edinburgh on the 29th May 1959, Mr. J. A. Aked was named Chairman for 1959–60, with Mr. T. R. Warren as a new Vice-Chairman, and Lt.-Col. F. N. Lucas and Mr. W. S. Fowlie were elected to the Committee. The 'sugar', which this year attracted an exceptionally large attendance, was provided by Mr. W. H. P. Leslie, who gave an informal talk, with impressive demonstrations, on 'The automatic digital recording of experimental values'.

Mr. Leslie compared the analogue type of instrument, such as the indicating or recording voltmeter, with the digital type and showed how the latter could range from a simple voltmeter to an instrument that will automatically plot curves from experimental results. The use of such equipment enables much otherwise-impracticable work to be done. Examples of hydraulic measurements were described. E. O. T.

News from abroad

TRINIDAD AND TOBAGO JOINT GROUP

Annual General Meeting

THERE was a very good attendance of nearly 50 members at our Annual General Meeting held on the 24th April 1959. The Honorary Secretary in his annual report recalled the highlight of the previous year, the visit of the President of the Institution of Mechanical Engineers, Air Marshal Sir Owen Jones, K.B.E., C.B., A.F.C., B.A., M.I.MECH.E., and the Secretary, Mr. Brian G. Robbins, M.SC., M.I.MECH.E., in May 1958. Apart from two functions in connection with this occasion two meetings had been held, and visits had been made to a local radio studio and to the marine oilfield and a drilling platform of Trinidad Northern Areas Ltd.

The main business of the evening was the election of officers and Committee members. Mr. W. T. Boyd, M.I.MECH.E., was elected Chairman with Messrs. K. W. Finch, M.I.E.E., and A. H. Richard, M.I.C.E., as Vice-Chairmen. At a Committee meeting held immediately afterwards Mr. D. P. J. Holbrook, A.M.I.E.E., was appointed Honorary Secretary.

After the meeting, which was held at Pointe-à-Pierre Club, members were able to get together over drinks before having a delightful supper. We were very pleased to have with us as a visitor Mr. C. H. White, M.I.E.E., M.I.MECH.E., and to welcome some of our newer members. D. P. J. H.

MIDDLE EAST JOINT GROUP

Bahrain meeting

THE 1958–59 Session ended with a meeting on the 30th April and 1st May 1959 in Bahrain. Fifty-eight members and guests were present from Manama and Awali, Bahrain, Kuwait, Qatar and the United Kingdom.

The meeting began on the 30th April at Jufair with the official opening of the new power station by H.H. Shaikh Sir Sulman bin Hamad Al Khalifah, Ruler of Bahrain, followed by our inspection of the station as the guests of the Bahrain State Electricity Board. Natural gas from wells south of Awali about 17 miles away is used as fuel. The present capacity consists of four 1 MW gas-engine generators which will ultimately become the station's standby sets, together with two 6·1 MW gas-turbine generators, all rated for full-load operation at an ambient air temperature of 95° F.

At the opening ceremony an audience of some 500 people listened to speeches by Sayed Hussein Mendil, assistant to the director of public relations, and Mr. D. Brammer, ASSOCIATE I.E.E., manager of the Bahrain State Electricity Board. After touring the station members were invited to cocktails with the Secretary to the Government of Bahrain, Mr. G. W. R. Smith, at his residence at Ghudibiaya, Manama.

Annual General Meeting

The following day the Annual General Meeting was held at the Ruler's new palace at Ghudibiaya when Mr. L. J. Cotterill, A.M.I.MECH.E., M.I.E.E., delivered his Chairman's report on the activities of the Group in the 1958–59 Session. During the year two successful meetings were held in Kuwait. The reduction in the number of meetings was attributed to circumstances beyond the control of the Committee, but the Chairman assured members that everything possible was being done to carry on the activities of the Group smoothly in future.

Although Iraq was practically closed for any Group activity Bahrain and Qatar and Persia were now open to hold meetings. The Chairman thanked the Committee and members for their spirit of co-operation and enthusiasm which had made his term of office a very enjoyable one.

Mr. Brammer then presented his paper entitled 'Electricity in Bahrain Islands'. This interesting paper dealt with the Bahrain electricity undertaking since it first began supplying public electricity in the Arabian Gulf in September 1929. He also discussed the difficulties of operating and maintaining the electricity supply system in Bahrain; this area is surrounded by the shallow salt seas of the Arabian Gulf and suffers in consequence one of the most humid and corrosive atmospheres in the world.

After refreshments the meeting was addressed by Mr. W. P. Auer of the Brown-Boveri Corporation who gave a short talk on the open-cycle combustion gas turbine which his company had provided for the new Jufair power station.

D. W. P.

AUSTRALIAN ATOMIC ENERGY COMMISSION

Research grants

THE Australian Atomic Energy Commission has awarded grants totalling almost £28 000 to support research under contract in seven Australian universities. The fields covered include chemistry; physics; geology; mining, electrical, metallurgical and chemical engineering; and the biological sciences. Of this sum, £4500 is for the renewal of three existing research contracts.

The grants have been made for work in fields which will contribute to the commission's own work in developing civilian uses of atomic energy. The new projects include research on equipment for training in radioisotope techniques, the effect of ionizing radiation on the metabolism of living cells, and the influence of magnetic fields on electrical breakdown in gases. The grant for work on the dynamic stability of turbo-alternators as affected by nuclear power plant has been extended.

OVERSEA ATTENDANCE REGISTER

DURING the period 18th May to 16th July 1959 these members called at the Institution building and signed the Attendance Register of Oversea Members:

CATER, C. (Fontanivent, Switzerland)
COLBOURNE, R. H. (Needham, Massachusetts)
COTTERILL, L. J. (Kuwait)
BENN, E. (Nigeria)
DOULGERIS, K. P. (Salisbury, Southern Rhodesia)
EMERY, W. J. G. (Salisbury, Southern Rhodesia)
GRANT, J. C. (Nairobi)
HARRIS, A. (Redwood City, California)
HEAD, S. (Sierra Leone)
HERCZEG, A. (Sydney)
LANGFORD, C. E. R. (Johannesburg)
LEHMANN, M. (Haifa, Israel)
MACLACHLAN, I. N. (Sydney)
MAYBERRY, A. C. (Karachi)
MITCHELL, J. E. (Salisbury, Southern Rhodesia)
MOORE, B. B. (Kirkuk, Iraq)
NETHERSOLE, H. J. H. (Johannesburg)
PALMER, T. M. (Sydney)
RAO, T. (Rangoon)
ROBINSON, E. J. (Belize, British Honduras)
ROGERS, J. E. (Nigeria)
SCHOLEY, D. H. A. (Dar es Salaam, Tanganyika)
SHARPLES, J. (Kuala Lumpur)
STEWART, P. H. (Montreal)
TOBIN, A. G. (Dublin)
TRAFFORD, W. (Singapore)
VERLEY, J. L. P. (Kampala, Uganda)
WILKINSON, C. D. (Accra, Ghana)
WINTER, D. F. (Brazil)
WORKMAN, A. H. (Abadan, Iran)

OFFICERS OF THE INSTITUTION

PATRON: H.M. THE QUEEN

Council, 1958-59

PRESIDENT
S. E. GOODALL, M SC.(ENG.), F.Q.M.C.

PAST-PRESIDENTS
W. H. ECCLES, D.SC., F.R.S.
THE RT. HON. THE EARL OF MOUNT EDGCUMBE, T.D.
J. M. DONALDSON, M.C.
PROF. E. W. MARCHANT, D.SC.
H. T. YOUNG
SIR GEORGE LEE, O.B.E., M.C.
SIR ARTHUR P. M. FLEMING, C.B.E., D.ENG., LL.D.
J. R. BEARD, C.B.E., M.SC.
SIR NOEL ASHBRIDGE, B.SC.(ENG.)
SIR HARRY RAILING, D.ENG.
P. DUNSHEATH, C.B.E., M.A., D.SC.(ENG.)
SIR VINCENT Z. DE FERRANTI, M.C.
T. G. N. HALDANE, M.A.
PROF. E. B. MOULLIN, M.A., SC.D., LL.D.
SIR ARCHIBALD J. GILL, B.SC.(ENG.)
SIR JOHN HACKING
COL. B. H. LEESON, C.B.E., T.D.
SIR HAROLD BISHOP, C.B.E., B.SC.(ENG.)
SIR JOSIAH ECCLES, C.B.E., D.SC.
SIR GEORGE H. NELSON, BART.
SIR W. GORDON RADLEY, K.C.B., C.B.E., PH.D.(ENG.)
T. E. GOLDUP, C.B.E.

VICE-PRESIDENTS
SIR WILLIS JACKSON, D.SC., D.PHIL., DR.SC.TECH., F.R.S.
G. S. C. LUCAS, O.B.E.
SIR HAMISH D. MACLAREN, K.B.E., C.B., D.F.C., LL.D., B.SC.
C. T. MELLING, C.B.E., M.SC.TECH.
A. H. MUMFORD, O.B.E., B.SC.(ENG.)

HONORARY TREASURER
E. LEETE

Ordinary Members of Council
J. A. BROUGHALL, B.SC.(ENG.)
PROF. M. W. HUMPHREY DAVIES, M.SC.
SIR JOHN DEAN, B.SC.
B. DONKIN, B.A.
J. M. FERGUSON, B.SC.(ENG.)
D. C. FLACK, B.SC.(ENG.), PH.D.
J. S. FORREST, D.SC., M.A.
R. J. HALSEY, C.M.G., B.SC.(ENG.)
E. M. HICKIN
J. B. HIGHAM, PH.D., B.SC.
F. C. McLEAN, C.B.E., B.SC.
B. L. METCALF, B.SC.(ENG.)
J. R. MORTLOCK, PH.D., B.SC.(ENG.)
R. H. PHILLIPS, T.D.
H. V. PUGH
J. R. RYLANDS, M.SC., J.P.
D. P. SAYERS, B.SC.
C. E. STRONG, O.B.E., B.A., B.A.I.
D. H. TOMPSETT, B.SC.(ENG.)
H. WATSON-JONES, M.ENG.
H. WEST, M.SC.

Chairmen and Past-Chairmen of Sections

Electronics and Communications
G. MILLINGTON, M.A., B.SC.
*J. S. McPETRIE, PH.D., D.SC.

Measurement and Control
J. K. WEBB, M.SC.(ENG.), B.SC.TECH.
*H. S. PETCH, B.SC.(ENG.)

Supply
D. P. SAYERS, B.SC.
*PROF. M. G. SAY, PH.D., M.SC., F.R.S.E.

Utilization
R. A. MARRYAT, B.SC.(ENG.)
*J. VAUGHAN HARRIES

Chairmen and Past-Chairmen of Local Centres

East Midland
D. E. LAMBERT, B.SC.(ENG.)
*J. D. PIERCE

Mersey and North Wales
J. COLLINS
*T. MAKIN

North-Eastern
A. T. CRAWFORD, B.SC.
*T. W. WILCOX

North Midland
J. D. NICHOLSON, B.SC.
*A. J. COVENEY

North-Western
PROF. F. C. WILLIAMS, O.B.E., D.SC., D.PHIL., F.R.S.
*F. R. PERRY, M.SC.TECH.

Northern Ireland
D. S. McILHAGGER, PH.D., M.SC.
*C. M. STOUPE, B.SC.

Scottish
R. J. RENNIE, B.SC.
*E. O. TAYLOR, B.SC., F.R.S.E.

South Midland
J. ASHMORE
*L. L. TOLLEY, B.SC.(ENG.)

Southern
G. BISHOP, B.SC.
*L. G. A. SIMS, M.SC., PH.D., D.SC.

Western
R. W. STEEL
*J. F. WRIGHT

* *Past-Chairman*

SECRETARY W. K. BRASHER, C.B.E., M.A., M.I.E.E.
Deputy Secretary F. JERVIS SMITH, M.I.E.E.
Principal Assistant Secretary F. C. HARRIS
Assistant Secretary N. C. STAMFORD, M.SC.TECH., M.I.E.E.
Chief Accountant F. H. JOB, F.A.C.C.A., A.C.I.S.
Editor-in-Chief G. E. WILLIAMS, B.SC.(ENG.), M.I.E.E.
Editor, *Journal* W. G. ASKEW, M.C.
Editor, *Science Abstracts* B. M. CROWTHER, M.A., PH.D.

Local Centre Officers

EAST MIDLAND CENTRE

Chairman: D. E. LAMBERT, B.SC.(ENG.)

Hon. Secretary: H. T. PRICE, Brush Electrical Engineering Co. Ltd., Loughborough

Hon. Asst. Secretary: J. BARNES, 13 Oakwell Drive, Ilkeston, Derbyshire

Cambridge Electronics and Communications Group

Chairman: N. C. ROLFE, B.SC.(ENG.)

Hon. Secretary: H. V. BECK, M.A., B.SC., The Cavendish Laboratory, Free School Lane, Cambridge

East Anglian Sub-Centre

Chairman: R. A. W. CONNOR

Hon. Secretary: CAPT. N. HILLER, B.SC.(ENG.), Cambridgeshire Technical College and School of Art, Collier Road, Cambridge

Hon. Asst. Secretary: J. H. HOWARD, 28A Cavendish Avenue, Cambridge

MERSEY AND NORTH WALES CENTRE

Chairman: J. COLLINS

Hon. Secretary: S. TOWILL, B.SC.(ENG.), 74 Hoole Road, Chester

Hon. Asst. Secretaries: D. BOYD, c/o The English Electric Co. Ltd., Liverpool Works, East Lancashire Road, Liverpool; J. N. FLETCHER, B.SC., PH.D., Brookhirst Switchgear Ltd., Northgate Works, Chester

NORTH-EASTERN CENTRE

Chairman: A. T. CRAWFORD, B.SC.

Hon. Secretary: R. BRUCE, M.SC., C. A. Parsons and Co. Ltd., Heaton Works, Newcastle upon Tyne 6

Asst. Secretary: R. W. SHIELD, 152 Edge Hill, Darras Hall, Ponteland, Newcastle upon Tyne

North-Eastern Measurement and Electronics Group

Chairman: G. H. HICKLING, B.SC.

Hon. Secretary: R. BRUCE, M.SC., C. A. Parsons and Co. Ltd., Heaton Works, Newcastle upon Tyne 6

Hon. Asst. Secretary: W. B. DOTCHIN, B.SC., Rutherford College of Technology, Northumberland Road, Newcastle upon Tyne 1

Tees-Side Sub-Centre

Chairman: L. F. ROBSON, B.A.

Hon. Secretary: D. W. PATTENDEN, 45 Stanhope Grove, Acklam, Middlesbrough

NORTH MIDLAND CENTRE

Chairman: J. D. NICHOLSON, B.SC.

Hon. Secretary: H. A. CARR, c/o A. Reyrolle and Co. Ltd. 20 St. Paul's Street, Leeds 1

Hon. Asst. Secretary: T. H. SCHOLES, c/o A. Reyrolle and Co. Ltd., 20 St. Paul's Street, Leeds 1

North Midland Utilization Group

Chairman: A. R. RUMFITT

Hon. Secretary: E. R. W. BRINKWORTH, c/o George Ellison Ltd., Norwich Union Building, City Square, Leeds 1

Sheffield Sub-Centre

Chairman: F. A. BENSON, D.ENG., PH.D.

Hon. Secretary: J. SYKES, 5 Mercia Drive, Totley Rise, Sheffield

Hon. Asst. Secretaries: J. E. CALDWELL, B.SC.(ENG.), 5 Cockshutt Road, Beauchief, Sheffield; D. N. ROBERTS, B.ENG., 303 Fulwood Road, Sheffield 10

NORTH-WESTERN CENTRE

Chairman: PROF. F. C. WILLIAMS, O.B.E., D.SC., D.PHIL., F.R.S.

Hon. Secretary: H. DIGGLE, B.SC.TECH., Transformer Engineering Dept., Metropolitan-Vickers Electrical Co. Ltd., Wythenshawe, Manchester 23

North-Western Measurement and Control Group

Chairman: T. KILBURN, M.A., PH.D., D.SC.

Hon. Secretary: R. W. FRYER, 2 Rossett Avenue, Timperley, Altrincham, Cheshire

North-Western Electronics and Communications Group

Chairman: R. FEINBERG, DR.ING., M.SC.

Hon. Secretary: J. DALTON, 12 Cedar Avenue, Claypool Road, Horwich, Lancs.

North-Western Supply Group

Chairman: J. WHITFIELD

Hon. Secretary: J. B. KILSHAW, System Planning and Design Engineer, North Western Electricity Board, No. 3 Sub-Area, Union Street, Oldham, Lancs.

North-Western Utilization Group

Chairman: J. N. M. LEGATE, B.SC.

Hon. Secretary: W. F. JARVIS, 8 Fairview Road, Timperley, Cheshire

North Lancashire Sub-Centre

Chairman: C. E. SMITH, B.SC.(ENG.)

Hon. Secretary: F. DAY, c/o North Western Electricity Board, 40/41 Lune Street, Preston

NORTHERN IRELAND CENTRE

Chairman: D. S. MCILHAGGER, PH.D., M.SC.

Hon. Secretary: R. L. MARRS, B.SC., 'Chez Moi', Mosside Road, Dunmurry, Co. Antrim

Hon. Asst. Secretary: W. H. FARMER, Room 49, Telephone House, 1 Cromac Street, Belfast

SCOTTISH CENTRE

Chairman: R. J. RENNIE, B.SC.

Hon. Secretary and Treasurer: J. H. P. DE VILLIERS, A.H.-W.C., Bruce Peebles and Co. Ltd., 19 Waterloo Street, Glasgow C.2

North Scotland Sub-Centre

Chairman: S. R. URQUHART

Hon. Secretary and Treasurer: K. J. MCCONNELL, c/o Jute Industries Ltd., Engineering Dept., Tay Carpet Works, Lochee Road, Dundee

South-East Scotland Sub-Centre

Chairman: J. MENDELSON

Hon. Secretary: G. I. THOMAS, B.SC., Ferranti Ltd., Ferry Road, Edinburgh 5

Hon. Asst. Secretary: J. B. MCPHERSON, 'Forth View', Haddington Road, Tranent, East Lothian

South-West Scotland Sub-Centre

Chairman: W. ADAM, B.SC.

Hon. Secretary and Treasurer: D. W. GREGORY, c/o Johnson and Phillips Ltd., 59 Berkeley Street, Glasgow C.3.

Hon. Asst. Secretary: D. R. ROLLO, B.SC.(ENG.), 44 Woodhead Avenue, Kirkintilloch, Glasgow

SOUTH MIDLAND CENTRE

Chairman: J. ASHMORE

Hon. Secretary: E. H. COX, Midlands Electricity Board, Mucklow Hill, Halesowen, Birmingham

Hon. Asst. Secretary: J. C. PYATT, c/o Central Electricity Generating Board, Nechells 'B' Power Station, Nechells, Birmingham 7

South Midland Electronics and Measurement Group

Chairman: J. S. ROEBUCK, B.SC.

Hon. Secretary: E. S. JOHNSON, c/o Telephone Manager, 63 Hagley Road West, Birmingham 17

South Midland Supply and Utilization Group

Chairman: J. R. ANDERSON, T.D., B.SC.(ENG.)

Hon. Secretary: H. C. FOX, George Ellison Ltd., Perry Barr, Birmingham 22B

North Staffordshire Sub-Centre

Chairman: R. W. PALMER

Hon. Secretary: P. W. R. GATLIFF, B.SC., The English Electric Co. Ltd., Stafford

Hon. Asst. Secretaries: A. P. BAINES, 51 Springfield Drive, Mosspitt, Stafford; (*Stoke*) P. FINCH, 14 Brookfield Avenue, Endon, Stoke on Trent; (*Stone*) C. E. WOOLLEY, K8 Raleigh Hall, Eccleshall, Staffs.

Rugby Sub-Centre

Chairman: E. M. PRICE, M.A.

Hon. Secretary: J. RICHMOND, M.B.E., B.ENG., 53 Vernon Avenue, Rugby

Hon. Asst. Secretary: R. W. ROBINSON, 51 Yates Avenue, Newbold Glebe, Rugby

SOUTHERN CENTRE

Chairman: G. BISHOP, B.SC.

Hon. Secretary: H. W. HOUSLEY, 15 Southdown Road, East Cosham, Portsmouth, Hants.

Hon. Asst. Secretaries: A. C. TREMAIN, B.SC.(ENG.), Municipal College, Portsmouth, Hants.; C. G. BRAMMER, 48 Brecon Avenue, East Cosham, Hants.

WESTERN CENTRE

Chairman: R. W. STEEL

Hon. Secretary: F. F. FREELING, Midlands Electricity Board, Bowling Hill, Chipping Sodbury, Bristol

Hon. Asst. Secretaries: (*Bristol*) W. D. MORGAN, 'Green Lea', Farleigh, Backwell, Nr. Bristol; (*Cardiff*) D. STEPHENS, 7 Clovelly Crescent, Llanrumney, Cardiff

Western Supply Group

Chairman: A. G. MILNE

Hon. Secretary: A. A. BECKINGSALE, Central Electricity House, 26 Oakfield Road, Bristol 8

Western Utilization Group

Chairman: C. E. DEW

Hon. Secretary: G. M. HUGHES-CALEY, The British Thomson-Houston Co. Ltd., 42 Baldwin Street, Bristol 1

Hon. Asst. Secretary: W. S. EVANS, The British Transport Commission, South Wales Docks, Roath Dock, Cardiff

Local Centre Officers (continued)

South-Western Sub-Centre
Chairman: CAPT. W. W. H. ASH, A.D.C., R.N.
Hon. Secretary: G. B. DEVEY, P.O. Engineering Dept., 23 Victoria Park Road, Exeter
Hon. Asst. Secretary: LT.-CMDR. A. O. H. ASHTHORPE, 151 Fort Austin Avenue, Crownhill, Plymouth

West Wales (Swansea) Sub-Centre
Chairman: T. GILL, B.SC.
Hon. Secretary: W. E. LEWIS, B.SC., PH.D., 19 Wimmerfield Crescent, Killay, Swansea
Hon. Asst. Secretary: D. H. HUGHES, 5 Hillside, Furnace, Llanelly, Carmarthenshire

Oversea Branches

BOMBAY BRANCH
Chairman: J. C. PATEL, B.SC.
Hon. Secretary: T. M. SHIVRAM, Services Engineer (North), B.E.S. and T. Undertaking, Electric House, Post Fort, Bombay 1

CALCUTTA BRANCH
Chairman: H. C. HARDY
Hon. Secretary: L. W. BRAZEL, The Calcutta Electric Supply Corporation Ltd., Victoria House, Calcutta

CEYLON BRANCH
Chairman: PROF. R. H. PAUL, M.A., B.SC.
Hon. Secretary: M. I. AZIEZ, B.SC., Electrical Engineer, Operations and Maintenance, Dept. of Government Electrical Undertakings, P.O. Box 540, McCallum Road, Colombo 10

IRISH BRANCH
Chairman: R. L. S. MCDOWELL, B.SC.
Hon. Secretary: J. MCKEEVER, B.SC.(ENG.), 'Dunluce', Willow Field Park, Dundrum, Dublin

Oversea Committees

AUSTRALIA
New South Wales
Chairman: H. B. WOOD, B.SC., M.E.
Hon. Secretary: D. K. MUIR, I.E.E. Box 701, G.P.O., Sydney

Queensland
Chairman: A. S. FAULKNER
Hon. Secretary: W. I. GEORGE, B.E., c/o The English Electric Co. Ltd., P.O. Box 406F, G.P.O., Brisbane

South Australia
Chairman: PROF. E. O. WILLOUGHBY, M.A., B.E.E.
Hon. Secretary: E. E. STORY, 25 Balham Avenue, Kingswood, Adelaide

Victoria and Tasmania
Chairman: J. WILSON
Hon. Secretary: D. P. DAVIES, M.SC., Pen Bryn, Mt. Macedon, Victoria

Western Australia
Chairman: K. W. TAPLIN, B.E.
Hon. Secretary and Treasurer: R. R. LAKE, B.E., c/o 132 Murray Street, Perth

CANADA
Toronto
Chairman: THE OVERSEA REPRESENTATIVE OF THE COUNCIL

INDIA
Madras
Chairman: R. WRIGHT, M.B.E.
Hon. Secretary: N. C. S. KUMAR, B.SC., c/o Associated Electrical Industries (India) Ltd., 35/5 Mount Road (First Floor), P.O. Box 2710, Madras 2

MALAYA AND SINGAPORE
Chairman: THE OVERSEA REPRESENTATIVE OF THE COUNCIL

NEW ZEALAND
Chairman: F. T. M. KISSEL, I.S.O., B.SC.
Hon. Secretary: E. H. R. GREEN, C.B.E., M.SC., Engineer-in-Chief, General Post Office, Wellington C.1

SOUTH AFRICA
Transvaal and Orange Free State
Chairman: THE OVERSEA REPRESENTATIVE OF THE COUNCIL

Oversea Representatives of the Council

ARGENTINA
B. G. BORISSOW, B.SC.(ENG.), c/o Metropolitan-Vickers Export Co. Ltd., Avda Roque Saenz Pena 636, 7° Piso, Buenos Aires

BRAZIL
E. WINSTANLEY, B.SC.(ENG.), The Rio de Janeiro Flour Mills and Granaries Ltd., Caixa Postal 486, Rio de Janeiro

BURMA
C. H. MELLOR, c/o Rangoon Electric Supply Board, 503/9 Merchant Street, Rangoon

CANADA
J. M. THOMSON, M.A.SC., PH.D., Ferranti-Packard Electric Ltd., Industry Street, Toronto 15, Ontario
(*Alberta*) PROF. J. A. HARLE, M.SC., Head of Department of Electrical Engineering, University of Alberta, Edmonton; (*Ontario*) F. S. BARTON, C.B.E., M.A., B.SC., 16 Roxborough Apartments, Laurier Avenue W., Ottawa, Ontario; (*Quebec*) F. L. LAWTON, B.A.SC., c/o Aluminium Laboratories Ltd., 1800 Sun Life Building, Montreal, Quebec

CAPE PROVINCE
C. G. DOWNIE, B.SC., c/o City Electricity Dept., P.O. Box 82, Cape Town

CEYLON
D. M. GILL, c/o Ceylon Rediffusion Service Ltd., P.O. Box 1002, Colombo

EAST AFRICA
A. O. COSGROVE, B.SC., The General Electric Co. Ltd., P.O. Box 5100, Nairobi
Deputy Representatives (*Uganda*): J. M. STOCK, O.B.E., M.ENG., Uganda Electricity Board, Kampala; (*Tanganyika*): J. H. GRIFFITHS, c/o Public Works Dept. Headquarters, Dar-es-Salaam, Tanganyika

FAR EAST
D. S. HILL, Reiss, Bradley and Co. Ltd., National City Bank of New York Building, 2 Queen's Road C, Hong Kong

FRANCE
P. M. J. AILLERET, Électricité de France, 12 Place des États-Unis, Paris (16e)
Deputy Representative: R. A. TELLIER, ING.É.S.É., c/o Électricité de France, 12 Place des États-Unis, Paris (16e)

INDIA
F. WADE-COOPER, Magnet House, Chittaranjan Avenue, P.O. Box 8974, Calcutta 13
Deputy Representatives: L. W. BRAZEL, The Calcutta Electric Supply Corporation Ltd., Victoria House, Calcutta
(*Bombay*) J. H. SMYTHE, B.SC., Greaves, Cotton and Crompton Parkinson Ltd., 1 Forbes Street; (*Delhi*) SHIV NARAYAN, SC.D., M.SC., B.E., M.A., B.SC., 2547 Nai Wara, 6; (*Madras*) J. MEEK, B.SC.(ENG.), c/o General Electric Co. (India) Ltd., Magnet House, Mount Road, P.O. Box 351

ISRAEL
B. F. MOSS, 94 Hayarkon Street, Tel-Aviv

MALAYA AND SINGAPORE
W. TRAFFORD, M.B.E., Telecommunications Dept. (Special Services), Fullerton Building, Singapore 1
Deputy Representative: F. R. WARDROP, B.SC.(ENG.), Central Electricity Board P.O. Box 1003, Kuala Lumpur

MIDDLE EAST
Appointment pending

NATAL
R. M. O. SIMPSON, c/o Electricity Dept., P.O. Box 147, Durban

NEAR EAST
H. D. FURBER, c/o Iraq Petroleum Co. Ltd., Electrical Engineering Dept., P.O. Box 150, Tripoli, Lebanon
Deputy Representative: PROF. R. W. SLOANE, M.A. PH.D., B.SC., Director of the Engineering Experimental and Service Laboratories, American University of Beirut, Beirut, Lebanon

NEW SOUTH WALES
J. T. ROLLO, I.E.E. Box 701, G.P.O., Sydney (telephone Sydney B0323, Ext. 313)

NEW ZEALAND
E. H. R. GREEN, C.B.E., M.SC., Engineer-in-Chief, General Post Office, Wellington C.1

PAKISTAN
A. E. C. GIBSON, c/o Associated Electrical Industries (Pakistan) Ltd., Post Box 4958, Karachi

QUEENSLAND
J. S. JUST, c/o Box 1067N, G.P.O., Brisbane

RHODESIA
A. B. COWEN, O.B.E., P.O. Box 377, Salisbury

SOUTH AUSTRALIA
G. H. MACHIN, B.E., c/o The Electricity Trust of South Australia, Box 412C, G.P.O., Adelaide

SWITZERLAND
L. W. HAYES, O.B.E., 43 Quai Wilson, Geneva

Oversea Representatives of the Council (continued)

TRANSVAAL AND ORANGE FREE STATE
A. W. LINEKER, B.SC., P.O. Box 7794, Johannesburg

UNITED STATES OF AMERICA
Hon. Secretary: R. H. BARCLAY, The J. G. White Engineering Corporation, 80 Broad Street, New York 4, N.Y., U.S.A.

VICTORIA AND TASMANIA
PROF. C. E. MOORHOUSE, M.E.E., Department of Electrical Engineering, University of Melbourne, Carlton N.3, Victoria
Deputy Representative for Tasmania: H. P. TUCK, M.E., B.SC., Associate Professor, University of Tasmania, Hobart, Tasmania

WEST AFRICA
J. HOUSTON ANGUS, Private Mail Bag 2031, Lagos, Nigeria

WEST INDIES
H. D. WALDEN, B.SC., Texaco Trinidad Inc., 6 Bon Accord Road, Point-à-Pierre, Trinidad

WESTERN AUSTRALIA
J. B. JUKES, B.E., The State Electricity Commission of Western Australia, Electricity House, 321 Murray Street, Perth

Joint Groups

ARGENTINA
Chairman: T. B. GLOVER, M.I.MECH.E.
Hon. Secretary and Treasurer: J. COMBES, A.M.I.C.E., c/o Percy Grant and Co. Calle Defensa 465, Buenos Aires, Argentina

BRITISH GUIANA
Chairman: G. A. R. FARQUHARSON, M.I.C.E.
Hon. Secretary: D. S. FAIRBAIRN, A.M.I.C.E., Drainage and Irrigation Department, P.O. Box 26, Georgetown

GHANA
Chairman: T. C. M. WIGG, O.B.E., M.A., A.M.I.C.E.
Hon. Secretary: C. D. WILKINSON, A.M.I.E.E., Telecommunications Engineering School Accra

GIBRALTAR
Chairman: E. V. ANDLAW, M.B.E., M.I.MECH.E., M.I.E.E.
Hon. Secretary: LT.-COL. R. A. LINDSELL, M.C., M.SC., M.A., M.I.E.E., R.E., 39 Europa Road, Gibraltar

HONG KONG
Chairman: G. B. GIFFORD-HULL, M.I.C.E.
Hon. Secretary and Treasurer: R. A. YOUNGER, A.M.I.MECH.E., Babcock and Wilcox Ltd., Alexandra House, Hong Kong

MIDDLE EAST
Chairman: C. G. MOORE, M.SC., A.M.I.C.E.
Hon. Secretary: D. W. PLATT, B.SC.(ENG.), A.M.I.MECH.E., A.M.I.E.E., c/o Kuwait Oil Co. Ltd., Ahmadi, Kuwait, Arabia

SINGAPORE/MALAYA
Chairman: S. E. JEWKES, O.B.E. M.I.C.E.
Hon. Secretary: T. CHURCHILL, A.M.I.MECH.E., Shell Co. of Singapore Ltd., P.O. Box 730, Shell House, Collyer Quay, Singapore

TRINIDAD AND TOBAGO
Chairman: W. T. BOYD, M.I.MECH.E.
Hon. Secretary: D. P. J. HOLBROOK, B.SC.(ENG.), A.M.I.E.E., c/o Trinidad Oilfield Service Ltd., P.O. Box 69, San Fernando, Trinidad

WEST AFRICA
Chairman: COL. E. H. WETTON BIGGS
Hon. Secretary: J. MEADE, A.M.I.E.E., Headquarters, Posts and Telegraphs, Lagos, Nigeria

Graduate and Student Section Officers

BRISTOL
Chairman: A. R. DANIELS
Hon. Secretary: C. R. WHEELER, Midlands Electricity Board, Bowling Hill, Chipping Sodbury, Nr. Bristol

CARDIFF
Chairman: J. K. PHELPS
Hon. Secretary: A. W. HART, 5 Tennyson Avenue, Llanwern, Newport, Mon.

EAST MIDLAND
Chairman: A. WREN, D.F.H.
Hon. Secretary: D. G. WALTERS, B.SC.(ENG.), The Grange, Thorpe Acre, Loughborough

IRISH BRANCH
Chairman: D. J. HOGAN
Hon. Secretary: A. J. DUFFY, 32 Upper Baggot Street, Dublin

LONDON
Chairman: L. A. HARRIS, B.SC.(ENG.)
Hon. Secretary: F. P. HARWOOD, 179 Sutherland Avenue, London W.9

MERSEY AND NORTH WALES
Chairman: E. G. FORREST
Hon. Secretary: D. G. ROBINSON, c/o Electrical Dept., Alfred Holt and Co., India Buildings, Liverpool 2

NORTH-EASTERN
Chairman: W. D. COUTTS
Hon. Secretary: R. HAWLEY, 26 Valley Drive, Low Fell, Gateshead, Co. Durham

NORTH MIDLAND
Chairman: G. W. GREEN
Hon. Secretary: D. B. WARDMAN, 6 Sunny Bank Grove, Bracken Edge, Leeds 8

NORTH SCOTLAND
Chairman: A. W. OGILVY
Hon. Secretary: P. M. WILL, B.SC., c/o Electrical Engineering Dept., Robert Gordon's Technical College, Aberdeen

NORTH STAFFORDSHIRE
Chairman: T. E. S. RICKARD, B.SC.
Hon. Secretary: D. J. AYLOTT, M.A., Transformer Works, The English Electric Co. Ltd., Stafford

NORTH-WESTERN
Chairman: G. B. POPPLE
Hon. Secretary: I. W. WRIGHT, B.SC., 77 Broadway, Worsley, Manchester

NORTHERN IRELAND
Chairman: A. A. MARSHALL
Hon. Secretary: J. B. HARSON, B.SC., 10 Chichester Road, Belfast

RUGBY
Chairman: P. J. G. HETZEL, M.SC.
Hon. Secretary: D. C. MACDONALD, B.SC.(ENG.), c/o Plant Engineering Dept., A.E.I. Heavy Plant Division, Rugby

SHEFFIELD
Chairman: B. G. CRYER
Hon. Secretary: M. F. BRACEY, B.ENG., Electrical Engineering Dept., The University, Mappin Street, Sheffield 1

SOUTH-EAST SCOTLAND
Chairman: G. E. WOOLLEY, B.SC.
Hon. Secretary: G. J. H. BROOKING, A.R.C.S.T., c/o Bruce Peebles and Co. Ltd., 37 Inverleith Place, Edinburgh 3

SOUTH MIDLAND
Chairman: J. M. HARVEY, B.SC.(ENG.)
Hon. Secretary: G. A. RALEY, 113 Castleton Road, Beeches Estate, Great Barr, Birmingham 22A

SOUTH-WEST SCOTLAND
Chairman: C. G. GORDON, B.SC.
Hon. Secretary: W. J. HALL, c/o The English Electric Co. Ltd., 200 St. Vincent Street, Glasgow C.2

SOUTHERN
Chairman: H. K. MADDAMS, B.SC.
Hon. Secretary: R. F. WHITWORTH, 23 Alton Grove, Portchester, Fareham, Hants

TEES-SIDE
Chairman: L. M. ARROWSMITH, B.SC.
Hon. Secretary: K. S. MILLINGTON, 14 Derwent Road, Redcar, Yorks.

Local Honorary Treasurers of the Benevolent Fund

East Midland Centre	*R. C. Woods*
Irish Branch	*A. Harkin, M.E.*
Mersey and North Wales Centre	*D. A. Picken*
North-Eastern Centre	*J. F. Skipsey, B.Sc.*
North Midland Centre	*E. C. Walton, Ph.D., B.Eng.*
Sheffield Sub-Centre	*F. Seddon*
North-Western Centre	*E. G. Taylor, B.Sc.(Eng.)*
North Lancashire Sub-Centre	*G. K. Alston, B.Sc.(Eng.)*
Northern Ireland Centre	*G. H. Moir, J.P.*
Scottish Centre	*R. H. Dean, B.Sc.Tech.*
North Scotland Sub-Centre	*P. Philip*
South Midland Centre	*Capt. J. H. Patterson, R.A.*
Rugby Sub-Centre	*P. G. Ross, B.Sc.*
Southern Centre	*G. D. Arden*
Western Centre (Bristol)	*A. H. McQueen*
Western Centre (Cardiff)	*E. W. S. Watt*
West Wales (Swansea) Sub-Centre	*O. J. Mayo*
South-Western Sub-Centre	*W. E. Johnson*